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No Relief in Sight From Pig Iron Shortage

Allocation of Foundry Iron Tonnage Will Make Non-Essentials Suffer—
Steel Foundrymen Object to Government Specifications—Scrap Prices Too High

FURTHER evidence of the impending shortage of foundry iron was developed during the last 30 days. The allocation of tonnage is being resorted to more generally and this practice is absolutely necessary on new government needs where the recipient of the order has not covered his pig iron requirements. Until a very recent date it was possible to divide such tonnages among a number of stacks, but none of these is able to further crowd overfilled order books through the first half of the year and, therefore, iron now is being commandeered for government work. During the next 60 days a tremendous tonnage of pig iron will be allocated and the foundries producing castings that are not counted among the essentials will have their supply of pig iron greatly curtailed.

Shortage Acute After July 1

No orders have yet been issued for the transfer of production from foundry to steelmaking grades and it is doubtful if such action will be taken in the near future. However, on July 1, a number of furnaces now operating on foundry grades will change over to basic, the shortage of which already is curtailing steel production. This further reduction in foundry iron output will be accompanied by the increased allocation of tonnage and shops not engaged on strictly government work will suffer more during the last half of the year than at any time since war was declared. At Washington, an effort is being made to relieve the situation by ascertaining whether a prospective recipient of a government contract has covered his future pig iron needs. It has been the practice to award these contracts without regard to a source of raw material supply, but it has been strongly urged that this practice be discontinued. It has been recommended, also, that a foundryman whose pig iron requirements are covered well into the future be given preference over one who will have to depend upon the government for his iron if he happens to be low bidder on certain government work.

Foundries are Doing Their Bit

A recent survey of the foundry industry indicates that practically 2000 casting plants are engaged on government work, either directly or indirectly, and for the purpose of gaging the threatened pig iron shortage, the American Foundrymen's War Service committee is sending a questionnaire to foundrymen asking them to specify their pig iron needs through the remainder of the year and the amount required for government work. They also will be asked to state whether they have contracted for their iron and what their consumption will be until the end of 1918. This information should prove of great value to the authorities at Washington, as it will prove that any further diversion of tonnage from foundry to steelmaking grades will greatly handicap the government in securing an ample supply of castings.

With the exception of basic pig iron, which was reduced $1 a ton, namely, from $33 to $32, all existing pig iron prices have been reaffirmed by the President. These will be continued in effect until July 1. Sales for the second half of the year have been retricted largely to the New England territory where one Buffalo interest sold approximately 40,000 tons. However, this disposed of practically the last of this iron to 1919. Some furnace interests in the east will take reservations only for last half. A small tonnage of foundry iron for delivery after July is available in the south, but this is insignificant in comparison with the large tonnage that has not yet been placed by the foundries for the last six months. During March, pig iron production increased 894,473 tons as compared with February, the output having totaled 3,212,715 tons. This increase, however, is inadequate to meet the needs of steel works and foundries which now is estimated to be in excess of 3,500,000 tons monthly.

Cast Iron Scrap Too High

The government cast iron scrap schedule of prices is meeting with growing opposition by the foundry trade. It is claimed that the maximum of $35 for cast scrap of cupola size is excessive and it is pointed out that recent sales below the maximum in practically all leading scrap markets is proof of the inability of scrap dealers to maintain this price. A deluge of letters from foundrymen all over the country is being received by the scrap committee of the American Iron and Steel institute, demanding a downward revision of these prices. Dealers have not yet been conceded a commission of 3½ per cent and it is

doubtful if they will be granted this or any other amount as a retainer for representing the purchaser. Effective April 1, steel scrap was reduced from $30 to $29 per gross ton.

For the purpose of increasing immediately the production of steel castings for the various departments of the government, the Steel Founders' Society of America recently addressed a communication to the various purchasing bureaus which suggests increasing the sulphur and phosphorus content in existing specifications. For many months, steel casting manufacturers have besieged Washington with requests for a slight increase in the maximum limit of the phosphorus requirement, but while their demands have been received respectfully, it seems almost impossible to obtain any government action. The steel casting manufacturers have contended that they are unable to comply with the phosphorus requirements of 0.05 per cent owing to the scarcity of low phosphorus pig iron and scrap and manufacturers of steel castings by the side-blow converter process claim that it is impossible for them to remain within the limits of 0.05 per cent sulphur.

The Steel Founders' Society of America has a membership of 176 steel casting plants and through a committee consisting of L. E. Thomas, chairman, Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.; H. E. Field, Wheeling Mold & Foundry Co., Wheeling, W. Va., and W. D. Sargent, Bayonne Steel Casting Co., Bayonne, N. J., it addressed the following communication to the various departments of the government that purchase steel castings:

It is recommended that steel castings specifications be revised to permit of a maximum of 0.08 per cent sulphur and 0.07 per cent phosphorus for castings manufactured by the Tropenas process, and an increase in the permitted sulphur content of castings made by the open-hearth process to 0.06 per cent phosphorus and 0.06 per cent sulphur.

This is necessary because it is now impossible to secure suitable raw material and fuel and the manufacturers are unable to guarantee a lower phosphorus and sulphur content than that indicated by this recommendation. Most of the purchasers of steel castings, including the large railroads of the country and some departments of the government already have agreed to these increases, in whole or in part, recognizing that the difficulties the manufacturers experience are due to causes beyond their control. It should be explicitly specified that when these revisions are adopted, they should apply to contracts or orders which have already been placed under the old specifications, but on which complete manufacture have not yet been made.

Heat Tests Recommended

One of the greatest differences between the requirements for government and commercial castings is in the number of test bars required. Insofar as possible, heat tests rather than individual tests should be used so as to cut down the number of tests for each heat. The testing of castings individually is of no advantage to the purchaser as there is no material difference in the test results secured from test bars from different castings in the same heat.

The only difference that might occur would be in annealing. Therefore, it is recommended that if more than one heat is represented in an annealing charge, one tension and one bend test shall be made from each heat. The annealing shall be determined by the use of annealing test lugs which should be attached to important castings when specified in advance and may be broken off by the inspector to examine the grain. The annealing lugs referred to shall consist of small pyramids approximately ½-inch square at the base and approximately 1 inch high, which can readily be removed with a hand hammer, and give a complete indication of the annealing of the castings.

It is recommended that the wording of the specifications of the American Society for Testing Materials covering the number of tests required and the placing of test bars on castings, and the method of casting unattached bars be adopted generally, as this wording has been proven to be clear and concise, and has met the general approval of the purchasers and manufacturers. This should be supplemented with a clause covering annealing test lugs about as follows:

Annealing test lugs approximately ½-inch section shall be attached when specified in advance to castings, which may be removed by the inspector to ascertain whether or not the annealing has been properly done.

The adoption of this recommendation would greatly reduce the number of test bars required on government work, and would assist greatly in putting the production of government castings on the same basis as castings for commercial purposes.

Central Inspection Bureau

The recommendation most generally made by the various manufacturers to the committee was that a central inspection bureau be established that could handle inspection for all branches of the government. This plan, if fully carried out, would make it possible for the government to handle this inspection with many less men, and enable them to have inspectors trained in inspecting steel castings devote their entire time to inspecting this class of material. In addition to saving salary and traveling expenses of inspectors, it would be greatly to the advantage of the government and the manufacturer to have experienced men devote their entire time to inspecting steel castings, who would be able because of their experience to exercise discretionary powers that is not now possible. It has been the experience of all foundries that many cases arise in which castings meet the spirit of the specifications, but vary in some details with the letter of the specifications. An inexperienced inspector, or one without proper discernment insists on castings meeting the letter of the specifications, which leads to untold delays and a great many rejections of castings that are perfectly suited for the purposes for which they are intended. The establishment of a central inspection bureau would make it possible to have a direct communication with those in authority so that questions arising can be passed upon immediately, and thus save delay of holding castings in the foundries until the communication goes through roundabout channels.

The British government found it desirable to combine under one head their inspection forces consisting of Lloyd's, the admiralty steel department and the department devoted to the supplying of steel for munitions, and further expedited the inspection by restricting it to samples instead of going into detailed examinations.

General Specifications

To accomplish the establishment of a central inspection bureau it would be necessary to have the various departments of the government adopt a single set of specifications, so that the same rules would govern the inspection and the chemical and physical requirements would be uniform.

It is the recommendation of the committee that every possible effort be made to have the various departments of the government adopt the essential details, if not the entire specifications, of the American Society for Testing Materials, but omitting Section VII, as their standard. In view of the fact that these specifications have been devised by a technical body made up of engineers, producers and purchasers of steel castings, and have been found after years of practical use to be practical and efficient, the committee finds no hesitancy in making this recommendation.

Physical Requirements

Grades 1, 2 and 3 of the army specifications are similar to grades B, D and A of the navy specifications, and there is but little difference between them and the three grades covered by the specifications of the American

Society for Testing Materials, as will be noted from the following table:

	Tensile strength, pounds, per sq. in.	Elastic limit	Elongation, per cent	Reduction of area, per cent
Army, No. 1.....	60,000	25,000	16	24
Navy, B	60,000	45%	22	30
A. S. T. M., Soft.....	60,000	45%	22	30
Army, No. 2.....	75,000	35,000	15	20
Navy, D	70,000	45%	22	30
A. S. T. M., Medium.....	70,000	45%	18	25
Army, No. 3.....	85,000	45,000	12	18
Navy, A	80,000	45%	17	20
A. S. T. M., Hard.....	80,000	45%	15	20

It will be noted that in the navy and A. S. T. M. specifications the yield point is expressed in the terms of the tensile strength, which in the opinion of the committee is proper. The committee recommends that an effort be made to have the army and navy accept the physical tests of the American Society for Testing Materials as standard for grades 1, 2 and 3 of the army and B, D and A of the navy, and another grade to correspond to grade F of the navy be added.

Number of Inspections

Most of the foundries complain of the number of inspections necessary under government specifications, which leads your committee to suggest that the inspection of government castings should be brought to conform to the inspection of commercial castings in order to save time and increase the production.

Government specifications are so written and applied that it is impossible to produce steel castings at anything like the same cost or quantity as steel castings subject to commercial specifications and inspections on account of the requirements which call for so much handling in the cleaning and finishing departments. This applies particularly to the requirements of an inspection of castings in the green. This is not commercial practice, and it congests the shops on account of unavoidable delays waiting for inspectors and extra crane service. This preliminary inspection seems unnecessary, as final acceptance of the castings is generally made in the machine shop. One trip of the inspectors could be saved by identifying the test bars by means of watching the break instead of having the inspector stamp the bars before they are removed from the castings.

Testing Machines

There should be uniformity between the various departments of the government covering the calibration of testing machines. At the present time a machine that has been calibrated may be acceptable to one department of the government whereas another department would demand a separate calibration. The expense of having machines calibrated is considerable, and it seems that one calibration by a standard laboratory when acceptable to one department should be acceptable to all departments of the government.

Location of Test Bars

Specifications should be so worded that the location of test bars and method of attaching unattached bars should be left to the judgment of the manufacturer, or at least the manufacturer and inspector should agree on these points, which is provided for in the wording of the specifications of the American Society for Testing Materials. Not infrequently inspectors demand bars to be attached at locations where it is impossible to secure a satisfactory bar either on account of the section of the metal, or the design of the casting or the location of the bar in the mold.

Records of Heats

The committee finds that most of the manufacturers of steel castings are put to a great deal of expense and delay on account of having to stamp the heat number on each casting. When it is considered that very frequently castings weigh under 1 pound in weight it is realized how much work is involved. It seems that this requirement should be done away with. This is also true of the requirement in some of the specifications that a casting record be kept of all castings, even when they are less than 200 pounds in weight. The committee suggests that small castings be handled in lots and not individually as regards records of heat numbers and testing.

Welding Castings

It is well known that steel castings, from the nature of the material from which they are made and the special requirements of the manufacture of the molds are bound to contain more or less defects. The causes are sufficiently known to the manufacturers who are constantly striving to overcome them. The inspector should have practical knowledge of the use of castings so that they can decide whether defects that are bound to occur are serious or not, and the use of welding should be permitted more than is allowed at the present time. Castings that are welded should be annealed afterwards to remove any strains that might be caused by welding.

Distorted Castings

There are many causes entering into the manufacture of steel castings that result in castings becoming distorted or warped. This is sometimes a question of design, and cannot be avoided. Distortion is also caused by lack of precaution on the part of the foundries, presence and absence of fins, carelessness or errors in preparing the molds, and many other causes, some of which can and some of which cannot be prevented. Information should be furnished the manufacturer before the castings are produced, as to which are important dimensions so that every precaution can be taken to prevent undue distortion, and a reasonable allowance should be made for variations that are bound to occur.

Castings acceptable in all other respects should be accepted unless it is shown that they are distorted on account of carelessness on the part of the foundry.

The manufacturer should not be held liable for any charges for straightening, welding, or otherwise making castings acceptable after they are received by the purchaser unless the foundry has been notified in advance, and shall have given the purchaser authority for doing such work at the manufacturer's expense.

Increased Sulphur Content for Steel Castings

By G Muntz

AN EDITORIAL recently was published in THE FOUNDRY in which existing inconsistencies in steel casting specifications were pointed out. The revision of these specifications now seems necessary, particularly in the upper limit of the sulphur content. Although we hesitate to make the statement, rule-of-thumb methods still prevail to a large extent in the metallurgy of steel casting practice. Specifications apparently never are questioned, and if a consumer demands 0.02 per cent sulphur in steel castings, every effort is made to meet this requirement which may represent only the whim of some engineer who never set foot inside of a steel foundry.

Some years ago we were requested to introduce copper-bearing iron in the manufacture of converter steel castings. The late Mr. Tropenas made some experiments with this metal, which proved that copper actually is beneficial and is not detrimental to converter steel. At that time copper-bearing pig iron was selling at a discount of nearly $6 a ton below copper-free iron. Then Mr. Tropenas ventured the prophecy that the time would come when consumers would pay a premium for copper-bearing steel. Certain railroads already have paid premiums on copper in rails and while an excess of $2 per ton over prevailing quotations was paid for copper-bearing rails, the steel manufacturer produced

this material at a cost of $6 per ton less than the copper-free rail.

We are strongly tempted to state that the time will come when a premium also will be paid for high sulphur steels. Such an assertion at present, however, only is a desperate attempt to fight against the tide of prevailing demand and the mass of specifications prevailing for low sulphur steel.No less an authority than Dr. J. S. Unger, of the Carnegie Steel Co., Pittsburgh, presented the case of high sulphur to a congress of automobile engineers on Jan. 6, 1916. The experiments he made were on a lot of 100 tons of steel, which represents a good average monthly output of an ordinary converter foundry. The tests represented only a slight departure from customary practice inasmuch as the only element experimented with was sulphur and this was varied in quantities from 0.032 to 0.230 per cent. From these different grades of steel Dr. Unger produced channels, chain links, rivets, car axles, etc., and some of the steel was drop forged into crankshafts by automobile manufacturers for the purpose of ascertaining respectively hot working performance and welding properties.

High Sulphur Results Surprising

The results of these experiments proved surprising, and in his address Dr. Unger stated that "in rolling the channels no tearing or red shortness was noticeable in the thin flanges of the higher sulphurs". In welding chain links "it was found that higher sulphurs weld perfectly and give good results, but that lowering the welding temperature about 100 degrees Cent. prevented any cracking or crumbling of the steel in welding". In drop forgings the high sulphur steels stood severe hot work just as well as the lower sulphurs, and when finished careful inspection failed to reveal any difference between the higher and lower sulphur steels. Dr. Unger gave further evidence of the lack of detrimental effect of high sulphurs and concluded his paper as follows:

"The tables and illustrations in this paper present the actual evidence obtained in investigating steels of different degrees of hardness with varying contents of sulphur. Wherever possible, variables which might affect common everyday use were made. The work was carried out by the ordinary methods practiced, and in such sizes as are manufactured in the mills or shops. A great deal of work covering other lines of manufacture has been done and additional work is either under way or in contemplation. Any person who has access to the necessary facilities should have no difficulty in duplicating the work done.

"The results presented speak for themselves and need very little comment. The author does not advocate paying no attention whatever to sulphur content of steel, but believes firmly that a steel containing less than 0.10 per cent is not necessarily bad, and that it will show little, if any, difference in quality when compared with the same steel of much lower sulphur, other conditions being the same."

An Important Statement

The following paragraph from Dr. Unger's paper I consider the most important statement made by him:

"The manganese of the three heats was 0.43, 0.62 and 0.67 per cent, respectively (carbons 0.09, 0.32 and 0.51). Attention is called to this point, as large quantities of steel containing from 0.070 to 0.120 per cent sulphur and 0.75 to 1.00 per cent manganese are made regularly for consumers who must have a steel especially fitted for rapid drilling, turning or threading purposes. The comparatively high manganese in this screw or nut stock has an appreciable effect on the hot working properties. This was not the case in the *low manganese steels* (the italics are ours) studied in this investigation."

What is the usual steel casting practice when it comes to correlating sulphur and manganese contents? Manganese is supposed to *mask* the effect of sulphur and, therefore, a high sulphur always corresponds to a high manganese in steel castings. However, in the light of Dr. Unger's statements it seems plausible to assert that the higher the sulphur the lower the manganese. When a casting is solidifying in a mold it is being subjected to just as strenuous treatment as a forging undergoing hot working, and this usually is shown by hot cracks in our high-sulphur, high-manganese steel castings. Recently, I visited a foundry where a specialty was made of cast steel motor truck wheels. Considerable trouble was experienced from hot cracking and this would not cease until the manganese accidentally was lowered in a heat which appeared to be unusually high in sulphur. We were advised that these wheels were machined and tested satisfactorily, but the foundryman was doubtful about their acceptance inasmuch as the sulphur specifications provided 0.05 per cent and the wheels contained 0.12 per cent.

Ferromanganese Squandered

It seems to me that we are traveling in a vicious circle. On the one hand, Dr. Unger has proved by experiment, of commercial magnitude, that high-sulphur, low-manganese steels work just the same as low-sulphur, low-manganese steels with apparently equal physical properties, and on the other hand we scour the market for low sulphur iron and coke to produce low-sulphur steel and squander our meager stock of ferromanganese to increase the manganese content and to effect the so-called *masking* of sulphur troubles.

While we do not possess the means of undertaking experiments of the magnitude of the one carried out by Dr. Unger, nevertheless we feel that the United States government would find it advantageous to replace some of the present manganese content of steel with sulphur to be brought about by the deliberate addition of this element. It might be suggested that the sulphur in cast steel motor truck wheels be increased from 0.15 to 0.25 per cent, with manganese from 0.20 to 0.25 per cent; carbon from 0.22 to 0.25 per cent and silicon, about 0.30 per cent. The time has arrived when deep consideration should be given to the sulphur content of steel castings and more attention should be accorded the results of the investigations made by Dr. Unger.

Peculiar labor and material conditions have forced a quantity of high-sulphur steel on the market. However, we do not see why the results of endurance tests in actual war service should be awaited before changing specifications which have been based more or less on theory. An experiment on a large scale is essential, both from the standpoint of the increased production and the conservation of our manganese supply, and the sooner it is made that much quicker will be removed the biggest hallucination of the steel foundryman.

Lead Production in 1917

The production of refined lead, both desilverized and soft, from domestic and foreign ores in 1917 is estimated at 599,000 tons, valued at $110,000,000. This is compared with 571,134 tons the previous year, valued at $78,816,000. The figures for 1917 do not include an estimated output of 20,000 tons of antimonial lead, valued at about $4,600,000 and compared with 24,038 tons in 1916. As a result of the great demand and high prices for lead that prevailed last year, about 5000 tons of secondary lead and over 4000 tons of secondary antimonial lead were recovered by smelting plants.

In replacing grinding stand spindles make sure that they are correctly installed. Standing in front of the machine, in the operator's position, the threaded end at the left to the observer should be the left hand thread. If through ignorance or carelessness the spindle is replaced wrong end to, the action of grinding is sure to cause the nut to work loose in which event a serious accident often occurs.

Handling Government Work in a Steel Foundry

How One Plant Has Solved the Problem—Many Inspections and Tests Are Made and Every Casting is Stamped With the Heat Number

By H Cole Estep

DURING the past few months many steel foundrymen have turned their attention to the production of ordnance castings. In every case this work has been undertaken in a thoroughly patriotic spirit, and in many instances government tonnage has been accepted at a considerable sacrifice and under conditions which have made it necessary to make extensive changes in shop equipment and methods. Without exception, however, the situation has been faced cheerfully, the main object of every foundryman turning out ordnance castings being to produce the best possible product without much reference to cost or contract prices. Experience has shown that castings made under government contracts for military purposes cannot be produced as cheaply as work of similar quality turned out for private individuals or corporations. Part of this additional cost is due to the necessity for enforcing specifications which are more stringent than commercial work requires. Additional expense also is incurred in providing facilities for carrying out the routine required by the government's methods, which call for the individual examination and marking of each casting. This is perhaps the most important particular in which government differs from ordinary practice. The ordnance department of both the army and the navy insist that the heat number be stamped on every casting regardless of its importance or size. In addition, each casting must be examined by a government inspector prior to annealing and again when it is finally finished. Numerous test bars are demanded, many of which must be attached to the castings in specified positions. All of these bars must be tested and their chemical and physical characteristics determined. The requirements of the government as to sulphur and phosphorus are stringent; there is also a lack of uniformity in the specifications of the different branches of the servce. Although this irregularity is slight, it is sufficient to make it necessary to use somewhat different methods on navy castings than on army work and still others on work for the Emergency Fleet corporation. This situation has been summed up in a report of a special committee appointed by the Steel Founders' society in which it is stated that the "government specifications are so written and applied that it is impossible to produce steel castings at anything like the same cost or quantity as those subject to commercial specifications and inspection, on account of the requirements which call for so much handling in the cleaning and finishing departments."

Through their organization, steel founders are exerting their influence to have certain apparently unnecessary requirements of the government modified in order to make possible the production of a greater tonnage of castings of suitable quality. While these negotiations are in progress, the melters are going ahead cheerfully under existing conditions, straining every nerve to realize the maximum output so urgently needed for the prosecution of the war. At the same time, various prominent foundrymen are giving close study to the problem of turning out castings economically under existing government regulations, and as a result, methods have been devised which have somewhat improved the situation. The Sivyer Steel Casting Co., Milwaukee, which is now devoting two-thirds of its large capacity to government work, has entered into this problem exhaustively. The methods devised by the Sivyer company have

FIG. 1—THE HEAT NUMBER MUST BE STAMPED ON EVERY GOVERNMENT CASTING REGARDLESS OF ITS SIZE—TWO MEN ARE REQUIRED FOR THIS WORK

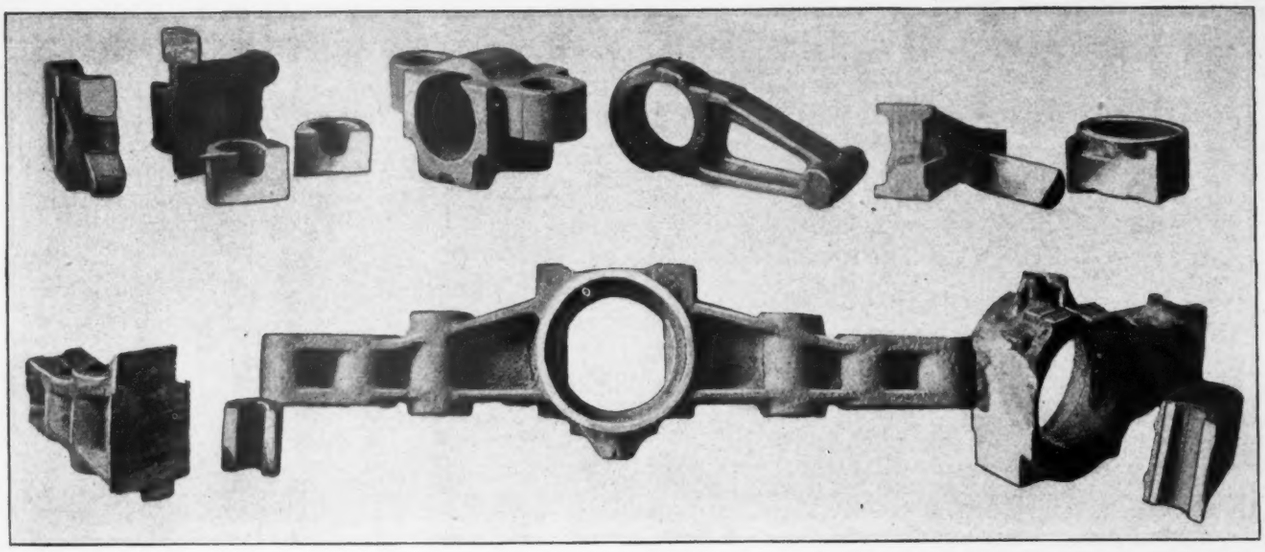


FIG. 2—BEFORE THE MOLDING PRACTICE IS STANDARDIZED SAMPLE CASTINGS ARE MADE AND SAWED APART TO REVEAL HIDDEN DEFECTS

been unusually successful in accelerating the production of ordnance castings and in reducing the cost of meeting the requirements of the government. These methods, therefore, are worthy of special attention.

The Sivyer company is making gun caisson and limber castings for 75 and 155-millimeter field guns, mount castings for 155-millimeter guns, 5-inch navy gun castings, as well as wheels and other special castings for motor trucks for the ordnance and quartermaster departments.

Three classes of castings are made for the ordnance department. They must conform to the following physical and chemical specifications:

No. 1 Cast Steel.—Elastic limit, 25,000 pounds per square inch; tensile strength, 60,000 pounds per square inch; elongation after rupture, 16 per cent; contraction of area, 24 per cent; sulphur under 0.07 per cent; phosphorus under 0.05 per cent.

No. 2 Cast Steel.—Elastic limit, 35,000 pounds per square inch; tensile strength, 75,000 pounds per square inch; elongation, 15 per cent; contraction of area, 20 per cent; sulphur under 0.07 per cent; phosphorus under 0.05 per cent.

No. 3 Cast Steel.—Elastic limit, 45,000 pounds per square inch; tensile strength, 85,000 pounds per square inch; elongation, 12 per cent; contraction of area, 18 per cent; sulphur under 0.07 per cent; phosphorus under 0.05 per cent.

All of the navy castings made by the Sivyer company are Grade *B*. These castings must conform to the following requirements:

Tensile strength, 60,000 pounds per square inch; elastic limit, 45 per cent of the tensile strength; elongation, 22 per cent; contraction of area, 30 per cent; sulphur under 0.05 per cent; and phosphorus under 0.06 per cent.

It will be noted that these specifications are severe particularly for No. 3 army and Grade *B* navy castings. The sulphur and phosphorus limits also are exceptionally stringent in view of present market conditions. In fact, this situation is so serious that the Steel Founders' society in its petition to the government recommends that the sulphur and phosphorus maximums be fixed at 0.06 per cent for open-hearth castings, with an allowance of 0.08 per cent sulphur and 0.07 per cent phosphorus in converter steel castings.

In view of these circumstances, the success of the Sivyer company in

FIG. 3—AXLE-BRACKET FOR GUN CAISSONS ARE MOLDED ON ROCK-OVER MACHINES

turning out a large percentage of satisfactory heats is commendable. The officials of the company attribute this success partially to close attention to detail and partially to the use of the electric furnace for melting the metal. The accompanying table shows the result achieved by the Sivyer company on a number of heats. This indicates clearly what the steel foundrymen of the country are doing to meet the government's needs. The successful production of steel castings for military purposes demands detailed attention to the molding practice. At the Sivyer plant all of the army and navy castings are made on molding machines in order to insure uniformity in the size and finish of the work. The machines also materially reduce the cost of the molding operations. Whenever a new job is taken up, it is carefully studied and an effort is made to develop the best possible procedure. To this end, before any work is started through the shop on a production basis sample castings are made, employing various methods of molding and gating, and sawed apart in order to reveal any hidden defects. A number of sample castings which have been subjected to this preliminary examination are shown in Fig. 2. As soon as a satisfactory method of molding is developed, the sample castings are submitted to the representatives of the government for approval. The molding method which has been found to produce sound castings is then standardized and the patterns and rigging arranged with a view to quantity production.

The care with which molding details have been worked out is indicated in Fig. 4, which shows the method of molding the drag for a 36 x 6-inch, plate-type military-truck wheel. A jar-ramming, roll-over, pattern-drawing machine built by the Herman Pneumatic Machine Co., Pittsburgh, is employed. The flask for the drag is 38 inches square and 12 inches deep. The cope, which is similar to the drag in its general outlines, is molded on a jar-ramming, turnover, pattern-drawing machine furnished by the International Molding Machine Co., Chicago. With two men on each machine, 60 molds are turned out per day. The arrangement of the gating is clearly shown in Fig. 4. The runner is in one corner of the flask, the gate being of the bottom-pour variety with several feeders leading into the lower rim of the casting. It will be noted that the brake drum is cast integrally with the wheel itself. The finished casting weighs 220 pounds. The weight of the rough casting with gates and risers attached is 290 to 300 pounds. This is one of the heaviest castings made by the Sivyer company, which specializes on light work. The wheels are molded in a special bay from which they are transferred by cranes to a convenient position near the furnaces for pouring. The wheel molds are poured with steel proportioned to meet the specifications of the American Society of Automobile Engineers. Its general characteristics are similar to No. 3 ordnance steel. Fig. 13 shows wheels of this type being machined. The principal difficulty encountered in making these castings arises from the strains occurring at the junction between the comparatively thin plate and thick rim. This has been overcome largely by the liberal use of risers and by pouring the steel at the proper temperature.

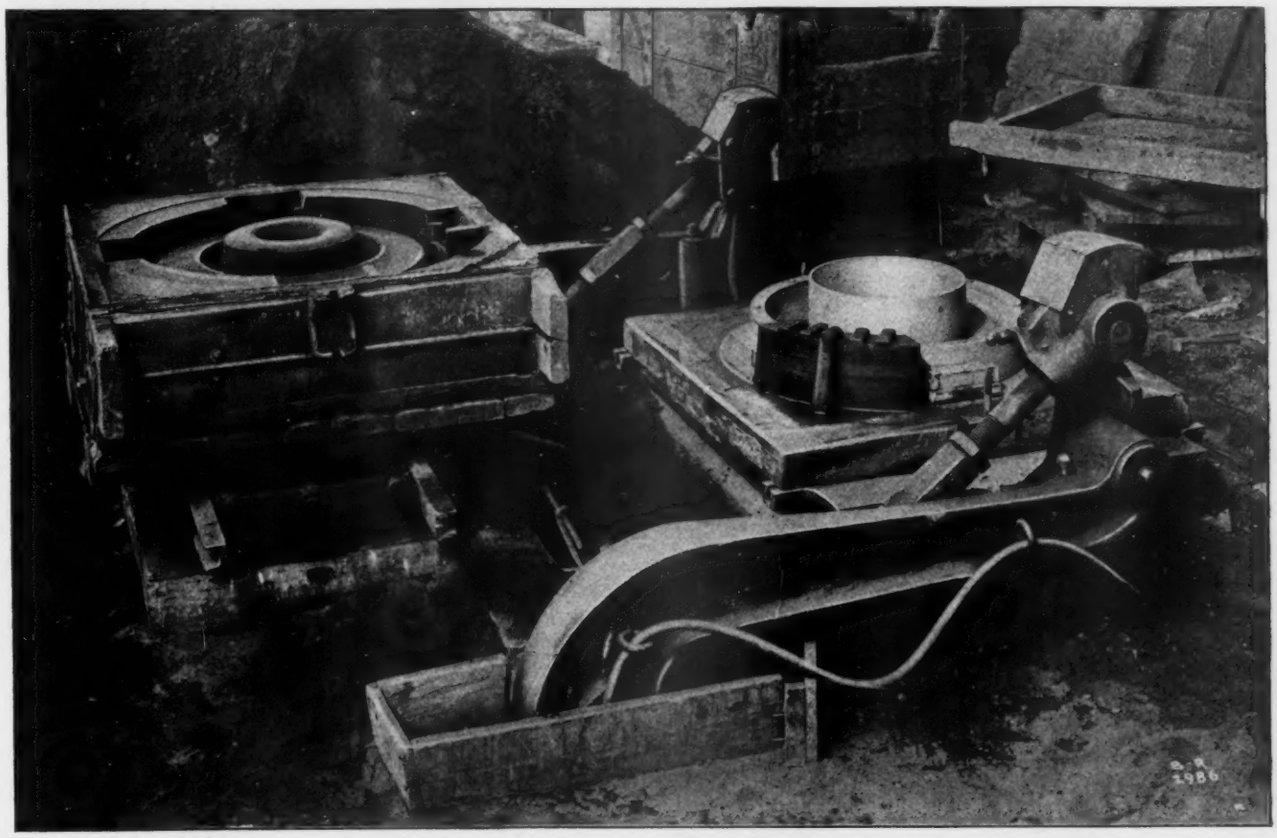


FIG. 4—MOLDING THE DRAG FOR A 36-INCH PLATE-TYPE MILITARY-TRUCK WHEEL ON A JAR-RAMMING, ROLL-OVER, PATTERN-DRAWING MACHINE

Another method of molding ordnance castings is illustrated in Fig. 3, which shows axle-brackets for 155-millimeter gun caissons. Power roll-over-draw machines of the standard type built by the Tabor Mfg. Co., Philadelphia, are employed for this work. The copes are molded on the machine at the left and the drags on the one at the right. As fast as the molds are completed, they are slid down the skids, shown in the fore-

ground of Fig. 3. These skids deliver the molds to the pouring floor where they are arranged as indicated in Fig. 6, which shows the core setting. Two castings are made in each flask and four men turn out from 30 to 40 molds a day including the core setting and closing operations. Round cores of a comparatively simple type that are amply proportioned, thus avoiding breakdowns and excessive repairs. A 3-ton heat is melted down in about 2½ hours in the Moore furnace. The furnace has been in operation only since December. The Snyder furnace has been installed for nearly two years.

The charges consist of specially selected scrap steel with occasionally a little low-phosphorus pig iron. The general practice, however, is to melt all-scrap heats. Croppings from shell forging plants are utilized together with springs, knuckles, and other high-grade steel scrap. Care is exercised to keep the sulphur and phosphorus in the charge low and all of the scrap is carefully analyzed before it is used so that the melter knows exactly how to proportion his charges to obtain steel of the correct composition.

During the heat the carbon is watched carefully and preliminary color tests for carbon are run from time to time in order to obtain the correct carbon content. The charges are proportioned to obtain the following percentages of carbon in the finished castings:

	Carbon, per cent
Class B navy steel	0.20 to 0.25
No. 1 ordnance steel	0.20 to 0.25
No. 2 ordnance steel	0.30 to 0.35
No. 3 ordnance steel	0.38 to 0.42

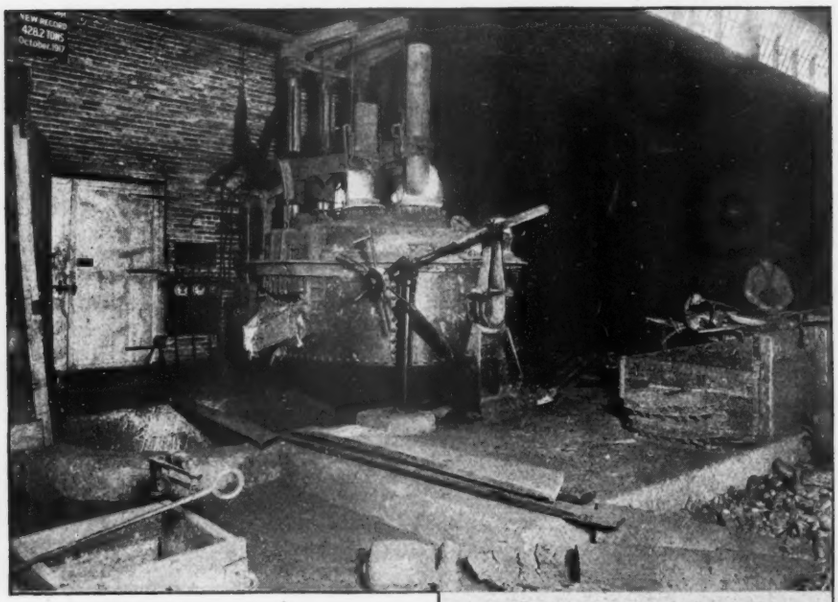


FIG. 5—ORDNANCE STEEL IS MELTED IN ELECTRIC FURNACES

are used. Before they are closed, the molds are carefully skin-dried with a gas torch. Steel flasks, 34 inches long and 22 inches wide, are employed. Both the copes and drags are 8 inches deep. The castings are poured from one runner in the middle of the flask, with centrally located gates extending to each mold. In pouring these castings No. 3 ordnance steel is used.

Electric Furnaces Used Exclusively

Electric furnaces are employed exclusively at the Sivyer plant for melting the metal for military castings. After considerable experimenting, the officials of the company have concluded that the electric furnace offers special advantages for this class of work on account of the possibility of exercising accurate control over both the temperature and composition of the heats. The freedom of electric steel from oxidation also is a factor.

Two furnaces are used, including a 1-ton, single-phase, single-electrode Snyder type furnace and a 3-ton, 3-phase Moore furnace built by W. E. Moore & Co., Pittsburgh. The latter is shown in Fig. 5 and its general characteristics are clearly indicated. Standard practice has been followed in designing the furnace and a special effort has been made to provide parts

How the Castings are Stamped

In ordinary steel foundry practice it is not customary to handle the castings individually in the annealing cleaning and finishing departments. As previously pointed out, however, the government insists that each casting be inspected individually and in addition demands that the heat number be stamped on the casting. Special arrangements are necessary to accommodate this practice. At the Sivyer plant, as soon as a heat is poured and the castings sufficiently cool, the molds are shaken-out and all of the castings together with the test bars for that particular heat are placed in a steel bucket which carries a tag bearing the heat number. Usually the tag consists simply of a piece of board on which the heat number is written with chalk. This bucket is transferred to the cleaning department where the castings and test bars are stamped with the heat number. This operation is shown in Fig. 1. Two men are required and every casting must be stamped. Stamps manufactured by James H. Matthews &

FIG. 6—A FLOOR OF AXLE-BRACKET MOLDS SHOWING METHOD OF OF SETTING CORES

FIG. 7—ANNEALING IS AN EXTREMELY IMPORTANT PROCESS IN MAKING ORDNANCE CASTINGS AND COMPLETE PYROMETER CONTROL IS NECESSARY. FIG. 8—A SAMPLE PYROMETER CHART SHOWING ANNEALING TEMPERATURES

Co., Pittsburgh, are employed. They are provided with movable numbers and are so arranged that the entire heat number may be marked on the casting with one blow of the sledge on the marker.

Another method of marking the castings is to print the heat numbers in the molds. The numbers then appear on the castings in raised figures. The Sivyer company has found this method less satisfactory than the one just described because it prevents the molds from being held from one heat to another and in case there should not be enough metal in the furnace to pour all of the molds on the floor those left over would either have to be scrapped or the numbers chiseled off of each casting and corrected. After the castings are properly marked with the heat numbers, the heads and gates are removed and the castings are sand-blasted. It is not possible to anneal the castings immediately since it is necessary to determine the chemical analysis of each of the test bars. The results of these analyses must be submitted to the government inspectors for their approval. This requires time and in the interval the castings must be stored conveniently and in a systematic and orderly manner.

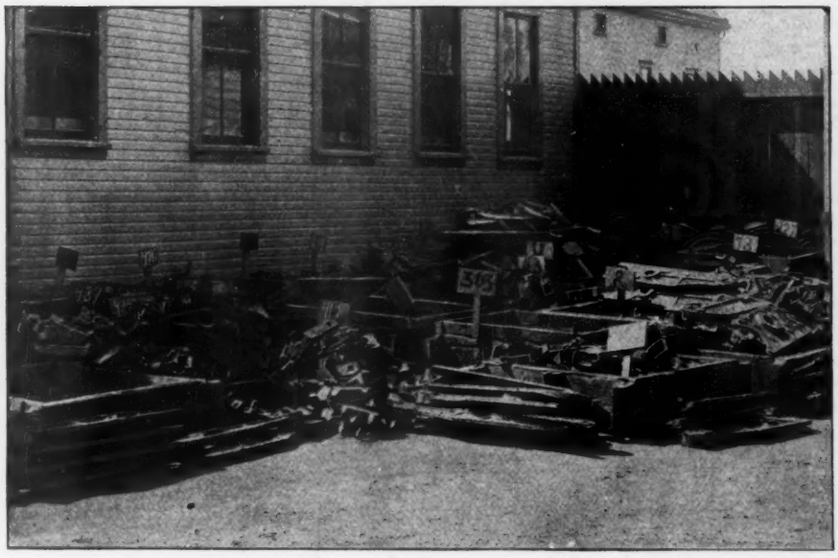


FIG. 9—WHILE THE TEST BARS ARE BEING ANALYZED THE CASTINGS ARE STORED IN BOXES IN THE YARD ACCORDING TO HEAT NUMBERS

Table I

Results of Tests of Castings Made to Government Specifications

Heat No.	Kind of steel	Elastic limit lbs. per sq. in.	Tensile strength lbs. per sq. in.	Elongation in 2 in., per cent	Reduction of area, per cent	Phosphorus, per cent	Sulphur, per cent	Silicon, per cent	Manganese, per cent	Carbon, per cent
299	No. 3	50,750	84,900	20.1	27.4	0.041	0.050	0.25	0.74	0.421
310	No. 3	54,000	100,400	17.5	20.4	.....	.....	....	....	.....
335	No. 3	46,870	89,500	18.7	23.5	0.045	0.055	0.50	0.80	0.427
284	No. 3	46,150	92,450	18.0	23.2	0.034	0.051	0.35	0.78	0.435
261	No. 3	48,650	101,450	11.5	20.2	.....	.....	....	....	.....
297	No 3	48,850	86,420	18.6	23.6	.....	.....	....	....	.....
314	No. 3	48,750	88,800	14.2	18.4	.....	.....	....	....	.....
291	No. 3	55,020	94,620	16.2	22.6	.....	.....	....	....	.....
348	No. 3	51,600	100,200	13.2	15.8	0.042	0.040	0.54	0.75	0.433
330	No. 3	47,000	88,350	18.0	20.6	0.051	0.049	0.36	0.85	0.371
3279	Class B	37,500	67,580	31.7	37.1	.....	.....	....	....	.....
3280	Class B	41,200	68,200	31.6	46.2	0.044	0.054	0.25	0.35	0.235

The castings, therefore, are taken out into the yard during this period and stored in rough wooden boxes according to heat number. Each box bears a sign giving the heat number of the castings in that particular lot. This temporary storage yard is shown in Fig. 9.

After the analyses are completed the casting must again be rehandled and heats of similar chemical composition assembled together for annealing. Before being loaded on the annealing-oven cars the castings are taken into the cleaning room, Fig. 10, where they are ground, chipped and then inspected both by the representatives of the manufacturer and the government. The government inspection is exceedingly minute, each casting being examined individually and stamped approved by the inspector if passed. Fig. 11 shows the government inspector at work examining green castings for gun caissons. Castings which are approved by the inspector are then piled up on the annealing oven cars, as shown in Fig. 12.

Some castings have to be welded to remove slight defects before annealing. The government inspector has authority to decide whether the casting should be reclaimed in this manner or scrapped. In some shops this has caused differences of opinion and losses of a serious nature. The experience of the Sivyer company along this line has been generally satisfactory.

An oil-fired annealing oven, some of the details of which are shown in Figs. 7 and 12, is employed. It is of the double-end, continuous, car type. Two cars are provided and while one

FIG. 10—EXTENSIVE CLEANING ROOM EQUIPMENT IS REQUIRED FOR PRODUCING ORDNANCE CASTINGS

FIG. 11—EACH CASTING IS EXAMINED AND STAMPED BY THE GOVERNMENT INSPECTOR BEFORE ANNEALING—THOUSANDS OF PIECES MUST BE HANDLED EVERY DAY

FIG. 12—AFTER THE CASTINGS ARE PASSED THEY ARE PILED ON THE ANNEALING-OVEN CAR FOR HEAT TREATMENT

load of castings is being treated the other car is unloaded and reloaded. The oven cars run on a depressed track so that loading platforms are level with the foundry floor.

The oven is of substantial construction with fire-brick walls and a heavy structural steel framework. In order to handle a greater output of annealed castings, the Sivyer company is now building a new annealing oven of a similar type.

Pyrometers Record Temperatures

Fig. 7 shows the pyrometer installation by means of which the heat is controlled. The details of the oil-burner also are shown in this illustration. The burners are of the air atomizing type and the flame enters the furnace at one end at the top. Suitable baffles and flues are provided inside the furnace to insure a uniform distribution of the heat.

The pyrometer installation was furnished by the Hoskins Mfg. Co., Detroit. The pyrometer is of the continuous recording type. An indicating instrument also is supplied and suitable switches are provided so that the temperature of the several thermo-couples inserted in various parts of the furnace may be determined. These couples are arranged on each side of the oven with one additional in the middle.

An effort is made to keep the maximum temperature during the anneal 30 degrees Fahr. above the critical point where the structure changes for the castings that are being annealed. This point, of course, varies with the chemical composition of the castings. This temperature refers to the actual temperature of the castings and not to the oven temperature. By experiment, the Sivyer company has learned that it is necessary to carry an oven temperature 50 degrees higher in order to be sure the castings are being annealed at exactly the correct figure. This difference between the temperature of the oven and that of the castings varies for different ovens and must be determined by experiment in each individual case.

The Sivyer company's experience also shows that it does not make much difference whether the castings are brought up to temperature slowly or rapidly. Every effort, however, is made to maintain the soaking temperature at a constant figure. The care taken in this direction is indicated clearly by Fig. 8, which is a reproduction of the recording pyrometer chart for a heat of No. 2 ordnance steel.

As this chart indicates, the oven was heated rapidly, in about two hours, up to a point slightly above 1500 degrees Fahr. This chart shows clearly the AC_3 and other critical points through which the castings passed; these points are indicated by sudden changes in the temperature due to recalescence, or to the sudden absorption of heat.

As the chart indicates, the heats are maintained at the soaking temperature for about four hours after which the oven is cooled very slowly. Approximately 10 hours are consumed in cooling the charge down to 700 degrees Fahr. The pyrometer record does not cover this entire period since it is not necessary to keep track of the temperature closely below 1000 degrees. The main idea at this stage of the work is simply to prevent the castings from cooling too rapidly. When the temperature has been brought down to 700 degrees, this point being indicated by a test made by the indicating pyrometer, the rate of cooling is accelerated.

As previously mentioned, each anneal must contain castings of approximately the same chemical composition, the carbon being the determining element in fixing the temperature of the critical point. The heats, therefore, are grouped for annealing according to chemical composition and about eight heats are annealed at one time. After the castings are annealed they are ready for the final cleaning and inspecting. The annealed test bars are machined and the required physical tests are made under the supervision of the government inspectors. A standard tensile testing machine is employed for this purpose. When the tests are passed, the castings from the corresponding heats are sand-blasted and tumbled, using the equipment shown in Fig. 10. The Sivyer company has found it necessary to install a large amount of cleaning equipment on account of the large number of small castings handled. An effort is made to clean the castings in as thorough a manner as possible in order that the finished product may have an attractive and workmanlike appearance.

After the castings are finally sand blasted and tumbled, they are again presented to the government inspectors for individual examination, stamping and approval, after which they are ready to be shipped to the machine shop.

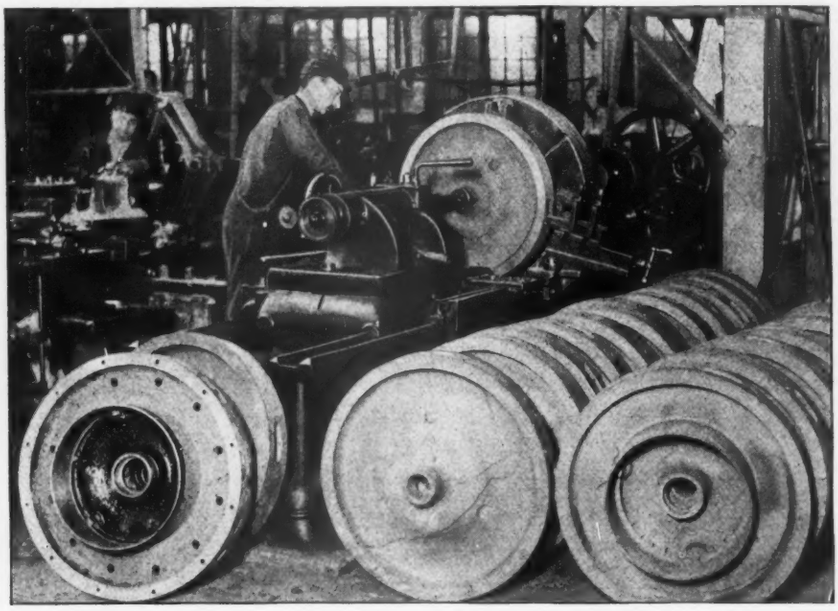


FIG. 13—ORDINARY LATHES ARE USED FOR MACHINING PLATE-TYPE MILITARY-TRUCK WHEELS

Consolidate Interests

The business of the late W. D. Dunning, Syracuse, N. Y., has been consolidated with that of the Boomer & Boschert Press Co. of that city and will be continued under the name of the latter. W. D. Dunning specialized in the manufacture of a core sand mixer and its production will be continued. The officers of the Boomer & Boschert Press Co. follow: R. E. Boschert, president; W. S. Dunning, vice president; C. A. Dunning, secretary and treasurer, and George E. Boschert, superintendent.

The Abell-Howe Co., 332 South Michigan avenue, Chicago, has been appointed representative of the Northern Engineering Works, Detroit, builders of electric overhead traveling cranes, hoists and foundry equipment.

Cooling Rate Affects Steel Casting Design---I

An Interesting Study of the Contraction of Steel is Presented, With a Practical Application to the Many Perplexing Problems of the Foundryman

By J G Fletcher

INHERENT weaknesses engendered by the slow solidification and cooling of heavy cast iron masses, such as the cylinders and heads of large hydraulic presses of high power, demand the use of a better and stronger material. It long has been recognized that the central zones of heavy cast iron sections are so coarsely crystalline, being weakened by graphitic carbon, and porous by reason of gas cavities and fissures due to contraction strains, that the allowable working stresses must be taken at very low values. The designer, therefore, often is obliged to increase the metal thickness of a casting beyond the point where the crystalline intercohesion in the center of the section is too weak to fix a tensile value for it. To make the cast iron section strong enough to withstand the necessary working load it frequently has been necessary to make it so massive that the center possesses practically no strength, due to slow cooling.

Ultimate Strength and Cooling

The estimated thickness for a 20-inch cast iron cylinder to withstand a bursting pressure of 5 tons per square inch we will assume is 16 inches. Such a mass of cast iron cools so slowly that it would be coarsely crystalline; the central third of the wall thickness would consist of metal having an ultimate strength of not more than 3 or 4 tons per square inch, thus reducing the actual thickness to 10 or 11 inches. In addition, the metal might be so porous that it would not withstand the hydraulic pressure to which it would be subjected.

The outer zones of a thick cylinder wall are stressed more lightly under hydraulic pressure than the inner zones nearest the bore. During the freezing and cooling of the metal the rate of cooling of the layer next to the bore is slower than that adjacent to the outer surface. This can be proved by comparing the values of C where C is the cooling surface in square inches of a ring of sections 1 inch deep and S equal the cubic contents of an annular ring. It is apparent that the value of $\frac{C}{S}$ for the outer ring is greater than that for the inner ring. In a cylinder 15 inches bore and 10 inches thick, the relative rates of cooling are 2.02 in the outer ring to 1.93 in the inner ring. By such considerations it will be found that cooling travels more slowly from the bore outward than from the outer surface inward.

Similarly, the contact heating of the mold at the outer circumference of the cylinder casting proceeds more rapidly than that at the surface of the core in the proportion in the case quoted—of 55 to 48. The core, therefore, becomes heated more rapidly than the outer mold surface and, as shrinkage proceeds, air contact at the outer circumference further speeds-up the cooling action there because the specific conductivity of air is greater than that of sand and other insulators. Also, the expansion of the core keeps the sand longer in contact with the metal and cooling is slowed-down thereby. Such investigations reveal the fact that coarse crystallization occurs in the layers nearest to the cylinder core, where it has been shown that cooling is slowest and where, in hydraulic service, the metal stresses are greatest. Fractured cylinders prove this, coarse graphite structures being revealed near the inner surface. Through this porous region the high pressure working fluid percolates and failure to resist such pressures in thick cylinders thereby is explained.

Thick Cast Walls Are Unreliable

Years ago it was learned that such cylinders should not have walls more than 10 inches thick, as it was found that beyond this thickness the cylinders were not increased in strength. At a meeting of the Institution of Mechanical Engineers in 1874, P. R. Jackson stated that 40 years before he had constructed 21-inch cylinders of hard, close-grained iron, and surrounded them with wrought iron hoops. Interior porosity was overcome by lining the cylinder with copper or brass, enabling heavy pressures to be carried. By similar reasoning, based on the laws of cooling and supported by tests taken from various portions of thick iron castings, it is evident that thicknesses exceeding 5 or 6 inches in castings made in sand molds are more or less unreliable, the interior of the heavy sections being fissured by graphitic flakes and porous, often containing gas inclusions as the result of imperfect feeding. Moreover, it has not been sufficiently recognized that the recalescence which occurs in steel when cooled below 700 degrees Cent. and is accompanied by dilatation or swelling, also occurs in cast iron. This is masked by the fact that the porosity which invariably accompanies coarse graphitic separation allows the internal dilatation to occur without visible or external deformation of the castings. However, internal expansion must be associated with a further opening out of the fissures which are primarily started when the graphite separates out during and immediately following the freezing of the iron.

Peculiarities of Malleable Cast Iron

In the manufacture of malleable cast iron the silicon content of metal used for heavy castings is limited to 0.5 per cent, the object being to prevent the formation of graphite in cooling, and Professor Howe has pointed out that in the United States it is common similarly to limit the silicon content for metal used in the casting of hydraulic cylinders. The lack of uniformity in malleable cast iron of any considerable thickness has often been pointed out and it is well known that thicknesses of 2 inches and over, even in metal containing less than 0.5 per cent silicon give trouble. The annealing necessary to decarburize the outer envelope leads to coarse-grained crystallization in the heart of the castings. The great difficulty in getting regular results in malleable cast iron is due largely to the impossibility of securing initial graphiteless uniformity in the pig iron used in its manufacture, or more correctly, in the unannealed castings. It has been rightly contended that silicon alone does not give a true index to the casting condition before annealing. The relation of silicon to the total and combined carbon is essential.

The foregoing has been introduced

Presented before a joint meeting of the Staffordshire Iron and Steel institute and the Birmingham branch of the British Foundrymen's association.

to illustrate the fickleness of the material dealt with by the malleable iron founder and indicates the difficulties of making heavy castings which will anneal satisfactorily. Heavy castings require metal having less than 3 per cent of total carbon and this is difficult to obtain. Moreover, the castings produced are brittle in the cast state and need careful handling during cooling, as the contraction frequently is as great as ¼-inch per foot. The lighter and thinner castings, approximately up to ½-inch thick can be made of relatively softer irons, lower in sulphur and higher in total carbon; they are easier to cast and to anneal.

Heavy Sections Make Difficulties

It has been shown, therefore, that there are certain fundamental difficulties in connection with the manufacture of heavy iron castings exceeding 5 inches in thickness and of malleable iron castings exceeding a thickness of approximately 1 inch. These heavy sections require a readily manipulated material and in steel the general characteristics sought for are found.

The general homogeneity of well melted steel enables the founder to deal with masses of almost any weight, although thicknesses above 12 inches, except in castings of easy form and such as can readily be fed, give trouble similar to cast iron in heavy masses. Segregations of carbon, sulphur and phosphorus in various combinations, together with slag and gas inclusions appear in the areas last to solidify. Steel freezes so rapidly that any such inclusions become entrapped to a much larger extent than in cast iron where, during the slower freezing, the gases and oxides can escape more readily to the freezing heads, their places being replaced by liquid feeding metal.

The higher casting temperature of steel, however, complicates the problem, as well as the expansion which accompanies recalescence during cooling. These two factors, with the accidental, though largely unavoidable presence of occluded gases and migratory slag, sulphide and phosphide particles, account for most of the difficulties which are experienced in steel founding. High casting temperatures are associated with extremely fluid metal though not infrequently with abnormally large quantities of occluded gases. Such hot, mobile steel is extremely erosive and requires mold surfaces of suitable material and of sufficiently rigid and uniform character. Molds for cast iron have to resist a rather acid metal at temperatures rarely exceeding 1300 degrees Cent. These can be made of a readily procurable sand mixture, porous in character and containing a fairly high percentage of binding elements and of volatile constituents which, at the temperature of pouring, leave ample exits for the escape of gas and moisture liberated at the mold surface when in contact with the fluid metal. As in iron foundries where the floor sand has been repeatedly used so as to yield bad and scabby castings so with steel molding sands and compositions. These can be used so often that the individual grains split into smaller ones until the percentage of fines becomes too great to allow of proper gas porosity or permeability and the added fireclay binding is found agglomerated in colonies of fusible character. This nonhomogeneity in a mass which should be uniformly porous and coherent leads to uneven skin expansions and contractions when under the influence of the adjacen molten metal, surface fissuring being the result. Even during the drying of the molds such fissuring can commonly be seen and these cracks are repaired more or less efficiently.

In the study of steel molding sands it is of paramount importance to recognize that hard rammed facing sands gradually lose their physical character, though not necessarily their chemical composition, through repeated using. These may be renewed by the addition of new, coarse material after the fines are sieved away, and used as backing, although the addition of coremaking materials such as sawdust and coke in the backing may be overdone and lead to abnormal expansion when drying the mold. Every steel founder appreciates the importance of the open, porous and elastic backing which is needed between opposing projections, the contraction between which, where the mold is too resistant, leads to skin fracture.

Face Wash is Important

The face washes are of vital importance and whether they are a partially volatile as in tar washes or graphite, or highly refractory, as in silica paints, there is need for great care in applying these in such a way as to effectively penetrate the skin surfaces of the molding composition. The wash should expand and contract with the sand or peeling is inevitable.

Researches on molding sands for steel castings should be of such a nature as to include compositions suitable for small as well as large and thick as well as thin castings; they should include the characteristics needed for core sands as influenced by slow or quick drying and cooling. The influence of runner stream erosion on flat and broken surfaces and the problem of tough yet elastic surface facings for resisting contractional defects between collars or flanges should be studied. The conclusion one must arrive at is that the research ground is the foundry and not the laboratory, though the chemistry and micrography must not be neglected. Observations only can be made use of in their application to commercial objects.

How Used Sand is Employed

The vital problem of the proper employment of used material and the doctoring of repeatedly used sands for various specific purposes such as backing, facing or core material alters with the type and weight of the castings required. Hence it must become necessary to adopt methods for controlling the disposition and circulation of new and used sands and to make mold and core drying a much more scientific operation than often is the case.

Most steel foundries operate at high pressure and the losses due to repaired molds after drawing badly-made patterns, careless swab washing and sleeking, poorly fitting or badly constructed flasks, together with the often disastrous results of the concussion of molds when setting for teeming, account for many of the defects which give steel castings a bad reputation and which sometimes appear only when a casting, after annealing and cleaning, is passing through a final costly machining operation.

The fundamental fact to be recognized in the freezing of molten iron or steel is that from 95 to 99½ per cent of the congealing metal consists of iron which tends to solidify as dendrites or fir-tree crystallites. The more slowly the cooling is effected the larger or coarser are these crystallites. They form first at the cool surfaces of the molds in which the liquid is poured and the axes of the dendrites are primarily normal to these cooling surfaces. These axial directions would persist until the crystallites growing from the opposite mold surfaces met were there not certain opposing influences. All molten iron and steel contains gases in solution. Each crystallite ejects its occluded gas into the surrounding liquid metal, which thereby is rendered lighter. The horizontal dendrites, therefore, whose ends may be compactly frozen together at the mold surface, tend to droop as they reach inwardly toward the axis of the ingot, and may break off near the drooping point and float off in any direction within the liquid

center zone. These dendrites freeze rapidly at the mold surface where their trunks and spines are not so robust as they become later when, thrust forward into the molten liquid, they grow more rapidly. No doubt convection currents within the liquid metal play a part in breaking off the dendrites before they attain maximum length. The outer envelopes of frozen metal, therefore, consist largely of dendrites whose axes are fairly normal to the mold or chill surfaces. Beyond this outer zone a position is reached where the crystallites droop and fracture, and from this point to the casting center the dendrites have their axes in confused orientation.

Effect of Impurities

When carbon is present and in the absence of the graphite liberating constituents silicon, nickel or aluminum, the freezing of the carbide of iron crystals in the mother liquor which surrounds the iron dendrites drives the liberated gases sharply toward the liquid center. Any metalloid present which tends to the retention of carbon in the combined state, such as manganese and chromium, promotes rapid freezing of the envelope at the mold surface and yields a thick skin of fine crystals whose axes are frozen at right angles to the mold surfaces. On the other hand, silicon, aluminum and nickel impede the formation of the carbide crystals and facilitate the iron dendrite growth, the development of the coarser structure associated with slower cooling and the more gradual release of the occluded gases.

The rate of cooling of a casting in a metal or sand mold is interesting to follow and the effect of varying thicknesses of mold relative to the thickness of steel cooled therein is a factor of importance. In an ingot cast in a chill or cast iron mold the relative fall in temperature of the ingot and the corresponding rise in the temperature of the mold vary according to the ratio of mass of mold to that of the ingot. It was calculated that an ingot cast in an iron mold having the same weight as the ingot dropped in temperature 920 degrees Cent., while the mold temperature increased 780 degrees Cent. In a mold having twice the weight of the ingot the temperature drop in the ingot is about 1200 degrees Cent. during a temperature rise in the mold of 510 degrees. An ingot was cast in sand in which the weight of the sand was twice that of the steel. The temperature drop in the ingot was found to be about 1420 degrees Cent. and the mean temperature of the mold increased 280 degrees. With a sand mold thickness of 16.3 inches surrounding a 10-inch ingot the temperature fall in the ingot was estimated to be 1565 degrees Cent. While the mean rise in the mold was 135 degrees the initial temperature of the steel having been taken at 1700 degrees Cent.

Table 1 illustrates how mass of mold affects the rate of ingot cooling and further shows how the rate of cooling varies throughout the thickness of a steel casting and how the mold correspondingly rises in temperature. It is difficult to state, without further experiment, what is the exact rate of heat travel, in inches per minute, through, steel, cast iron and sand.

The effect of a thick chill or metal mold emphasizes the cooling action on the zones of the ingot nearest to the mold where the temperature gradient (fall) is greatest. The points developed by the tests are that when the thickness of the metal mold exceeds that of the casting, any further mold thickness does not greatly influence the rate of cooling action. From Lord Kelvin's data the diffusivity of heat in iron is from 15 to 20 times that of sand, hence the speed of cooling of a casting in an iron mold is approximately 15 times greater than in a sand mold. Therefore, an ingot which falls in temperature from 1500 to 550 degrees Cent. in an iron mold in 20 minutes will cool down to the same temperature in a sand mold in from six to seven hours.

Curves that were plotted indicate that the effect of increasing the mold thickness in chilling or cooling the steel casting is greatest when the ratio of thickness of mold to that of the casting is below 0.25 in cast iron molds and below 1 in sand molds. In the latter the rate of cooling diminishes progressively as the thickness of the sand mold exceeds twice that of the steel casting. When the sand mold thickness exceeds eight times that of the casting further chilling action of the sand is nil.

The practical application of the foregoing investigation is obvious. It can be proved, therefrom, that a cast iron chill one-half the weight of the steel ingot cast in it cannot withstand the heat to which it is subjected, the temperature of the inner surface reaching the melting point of cast iron. Similarly, a sand mold only 1 inch thick surrounding a 10-inch diameter casting would not conduct away the heat sufficiently rapid to prevent the surface of the mold attaining a temperature of approximately 1330 degrees Cent. At this temperature it would probably soften or fuse, unless the sand were backed by material such as cast iron which would conduct the heat away more rapidly than the sand.

Rapid Conduction of Heat Desirable

In early Sheffield ingot practice the advantages of the rapid conduction of heat away from the mold were recognized and for years, ending with a disastrous explosion, water-cooled molds were used. Recently one English steelmaker returned to the water chilling of molds by casting water pipes within the mold walls through which the cooling water is made to circulate. The author had experience in the use of water cooling in the Harmet fluid steel compression process, where the thick molds were further hastened in their cooling action by spraying water over the exteriors. A fine crystalline structure of the outer envelope of the ingot resulted. A study of the foregoing will show

Table I

How Iron and Sand Molds Affect the Rate of Cooling of Ingots and Steel Castings

Ratio of the weight of the mold to weight of ingot. Iron mold:	Ingot diameter, inches	Thickness of mold, inches,	Ratio, $\frac{F^1}{R}$	Approximate time cooling, minutes
1.0	10	2.25	1.17	31
1.5	10	3.10	1.76	23
2.0	10	3.90	2.35	19
3.0	10	5.30	3.52	14
4.0	10	6.50	4.69	11
8.0	10	9.75	9.38	6
Sand mold				
1.0	10	6.50	2.75	225
1.5	10	8.65	4.09	160
2.0	10	10.50	5.46	130
3.0	10	13.60	8.18	92
4.0	10	16.30	10.92	67
8.0	10	24.75	21.84	37
16.0	10	36.75	43.68	19

[1]In ratio $\frac{F}{R}$ F is the fall in the mean temperature of the ingot; R is the rise in the mean temperature of the mold.

that the rate of cooling of a casting having thick and thin sections may be dangerously different in these different sections of the same casting. The outer and rapidly freezing envelope may be passing the temperature zone of recalescence, with its accompanying dilatation, while the inner metal may be just freezing. In the case of castings having a higher manganese content than 1 per cent, with silicon under 0.20 per cent, the dilatation of the steel when passing 700 degrees Cent. is severe and may readily burst or tear the skin. Here the austenitic passes to the pearlitic state abruptly, the more so as the carbon content is high. There is a limiting ingot mold thickness to insure freedom from skin cracking, though the latter is influenced by rate of pouring and other factors. This thickness bears a fixed ratio to the ingot diameter and it also has been observed that the length of the ingot has a bearing on the skin bursting pressure.

Internal Pressure in Cooling

The first rapidly frozen envelope shrinks away from the ingot mold. The liquid steel contained within the interior has a pressure heavy enough to burst the skin and in the early moments of the ingot's life, these skin fissures allow liquid steel to exude and become frozen at the mold face. If the mold is not massive enough, this skin fissuring produces a rough surface in the ingot and often a kind of cold shut occurs which is aggravated when the mold sides have been splashed by rapid and drastic pouring. It was computed that in a 20-inch ingot, 6 feet long and just frozen, the envelope having been assumed to be 0.1 inch thick, the bursting pressure on the wall of the freezing envelope near the bottom of the ingot is about 20 pounds per square inch. The tensile stress resisting the liquid pressure would be about 1 ton per square inch of section of the envelope, which at white heat would readily burst or tear. The sharp corners of a square or polygonal ingot freezing more rapidly than the sides, yield a stronger envelope, hence tearing is more or less avoided, provided the mold is thick enough. The weakness of a cylindrical chill mold is thus explained and the effectiveness of ingots cast with the small end down and poured slowly, is evident, compared with tapered ingots cast in molds having the large end at the bottom.

In sand molds the skin fracture under high pressure head, especially in massive castings, is readily detected. Here the envelope cools slowly and is very thin for a considerable time after casting. The fissures, however, are rapidly healed, although certain worm marks on the surface tell the history of the early moments of freezing, skin fissuring and healing.

In multiple castings poured in one mold it is not unusual to trace defects to the failure to consider the slow rate of cooling of closely grouped heavy parts. For example, an attempt was made to cast vertically four projectiles in a cluster and run through a central runner. Too thin a wall of sand was allowed between the inner surfaces of the castings and these parts, therefore, cooled more slowly than those exposed to the thicker mold surfaces. They were coarsely crystalline and in many cases became badly honeycombed, being receptacles of slaggy particles and occluded gases. Sand adhered to these inner surfaces because the temperature of this sand reached its fusion point. The difficulties experienced with thin cores in heavy castings only can be overcome by freezing the metal in their immediate vicinity by introducing some chilling media such as wire nails or cooling plates.

Table II

Results of Heat Diffusion Tests in Iron and Sand Molds

Minutes after casting:	Mold temperature, degrees, Fahr. Iron	Sand
0	102	72
1	120	74
2	174	76
3	218	..
4	242	78
8	302	82
10	312	90
12	317	99
14	319	110
16	320	121
20	...	141
25	...	159
30	...	174
35	...	182
40	...	187
45	...	191
50	...	191

In the study of rapid chilling the author found that Harmet quickly frozen and compressed steel ingots were denser than ordinary chill cast ingots, the increase in density being closely proportional to the volume of the pipe in an uncompressed ingot of similar total weight. Again, an ingot was cast with a central, metal, solid core, in a thick chill iron mold. The metal on freezing did not grip the central metal core, which was easily withdrawn. In such a case the author found it possible to so proportion the mold to the core diameter, as to insure an absence of contractional grip on the core. The withdrawn chill core is then smaller in diameter than the hole in the ingot center.

If the phenomenon of contraction is due simply to crystalline shrinkage then in the foregoing case the ingot should have gripped the central bar core. For years the author has contended that the occluded gases in steel are inseparably connected with the phenomenon of contraction and by assuming that such is the case, has overcome many of the usual contractional difficulties.

An instructive series of tests were made for the purpose of finding the relative heat transmission of fine and coarse molding sands per unit of time. A heating plate was uniformly raised in temperature by electrical means, a 6-inch diameter hoop, 2 inches deep, having been filled with the sand, which rested directly on the heated plate. The bulb of a thermometer was submerged ½-inch into the sand and readings were taken every minute during a temperature rise from 80 to 200 degrees Fahr. It was found that the rate of heat conduction up to about 150 degrees Fahr. was the same for both fine and coarse sands. Beyond 150 degrees the rate of conduction was much higher for the fine sand, 200 degrees being attained by the fine sand in 44 minutes against 59 minutes for the coarse sand. When the sand is dry the rate of heat conduction is much more rapid in the fine sand than in the coarse, being about twice as rapid between temperatures of 80 and 150 degrees Fahr. At about 180 degrees the conduction rate slows down somewhat, rising again at from 200 to 220 degrees. Above this temperature the heat conduction rates for both fine and coarse sands do not vary greatly, although the fine always has a higher conductivity than coarse sand. Mixtures of fine and coarse sands conduct heat more rapidly than fine sands; they are more closely packed and hence a larger area of contact between the particles and the average interstitial spaces are smaller than in the case of either fine or coarse sands separately used.

Comparative Tests of Heat Diffusion

A further comparative test of heat diffusion through sand and cast iron molds is given in Table II. In each case the mold was 13 inches outside diameter, 5½ inches bore and 6 inches deep. Cast iron at about 1240 degrees Cent. was poured into the mold and the temperature was taken at a point halfway down the mold and ½-inch below the outer surface. The temperature fell to 160 degrees Cent. in the iron mold in 14 minutes; in the sand mold (green sand skin dried) the temperature dropped to 87 degrees in 45 minutes.

Molding a Superheater Locomotive Cylinder

The Production of This Intricate Casting Involves the Setting of a Large Number of Cores, the Details of Which Are Fully Described

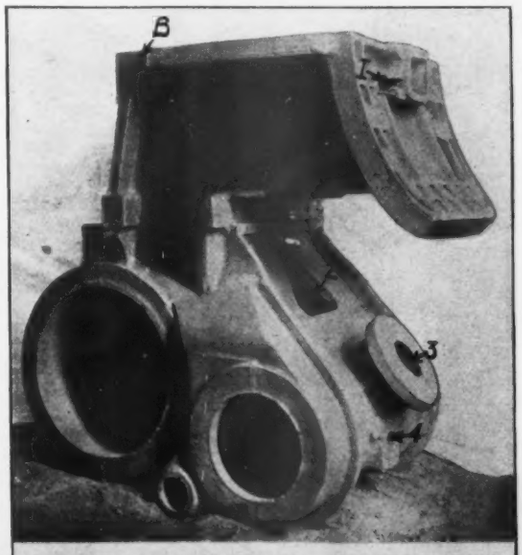
By R H Palmer

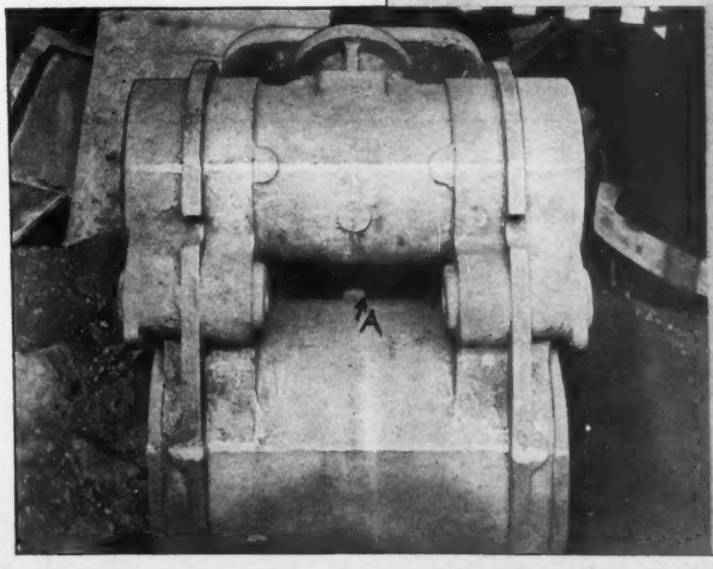
AMONG the many recent improvements in locomotive design and construction, the superheater ranks as one of the most important, since it effects great economies in fuel consumption and considerably adds to the steam efficiency. The cylinders for superheater locomotives are made of gray iron, the castings being exceedingly intricate and the molding operation taxes the ingenuity of the foundrymen on account of the large number of cores that must be set. Figs. 1, 2 and 3 are different views of a locomotive cylinder casting for the New York, New Haven & Hartford railroad.

The cylinder pattern is illustrated in Fig. 8. It consists of cope, cheek and drag sections. The saddle part of the pattern which forms the drag is shown at the left, Fig. 8. It contacts with the cheek at the edges *A*, shown on the drag and the cope, respectively. This forms the saddle of the cylinder on which a part of the locomotive boiler is supported. The cope part of the pattern is illustrated at *I*. Other parts of the pattern are indicated as follows: *B*, coreprint; *C*, steam pipe nozzle with coreprint *D*; *F* is a coreprint, loose on the pattern, for the top core forming the inside of the casting; *G* is the coreprint for the piston valve core, which extends up to the print *H*, for the main barrel core of the cylinder that also forms a part of the outside of the cylinder; *J* is a loose extension on the side of the pattern, which is left in the mold when the cheek part of the pattern is drawn from the mold; *K* is a coreprint for the core forming a part of the flange where the two cylinders are machined and bolted together and *L* forms the nozzle with its print *M*.

The cheek part of the pattern is placed on a mold board, as shown in Fig. 4, and the cheek flask *B*, extending from *C* to *D*, is placed over it. The pattern is faced with a mixture of equal parts of coarse molding and fire sand, to which flour is added in the proportion of one of flour to 18 of sand. This facing is backed with tempered sand from shaken-out cylinder molds, and if the sand is badly burned, it is tempered with a mixture of clay and water to restore the necessary bond. If a desirable grade of gravel may be obtained, the proportion of molding sand in the facing mixture is reduced and is replaced by gravel and a smaller amount of flour is added. A dry core binder also may be substituted for the flour.

When the successive rammings of sand have reached points *E* and *F*, Fig. 4, a parting is made and covering core *G* is placed around coreprint *D*, Fig. 8. After this core is located, it is raised and the steam nozzle, *H*, Fig. 4, is drawn from the mold and the covering core *G* is returned to position. The ramming then is continued until the sand reaches a point where it contacts with the cast iron bar *N* and the side bars, *M*, Fig. 4. These three bars which support the overhanging sand forming the saddle of the cylinder, are bolted to the outside of the cheek flask. The bars are attached in this way to facilitate their removal when the casting is





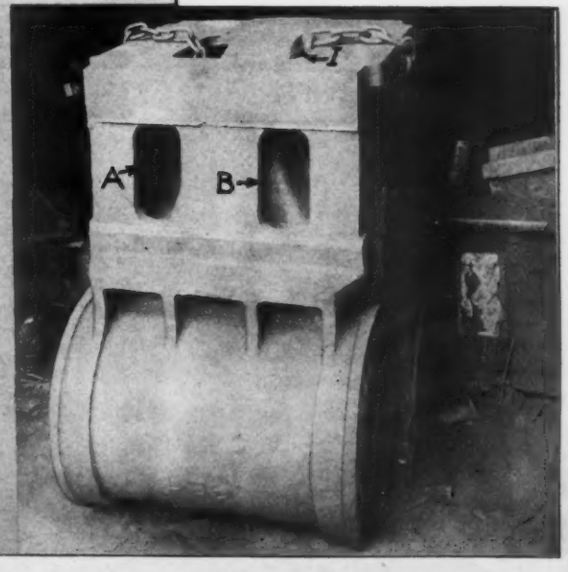


FIG. 1—SUPERHEATER LOCOMOTIVE CYLINDER CASTING
FIG. 2—FRONT VIEW OF CYLINDER AS INSTALLED
FIG. 3—ANOTHER VIEW OF THE CYLINDER

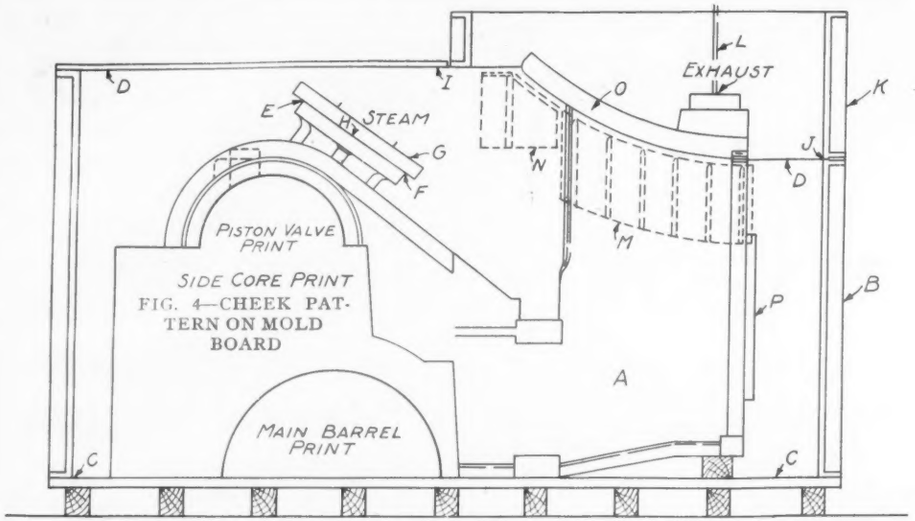


FIG. 4—CHEEK PATTERN ON MOLD BOARD

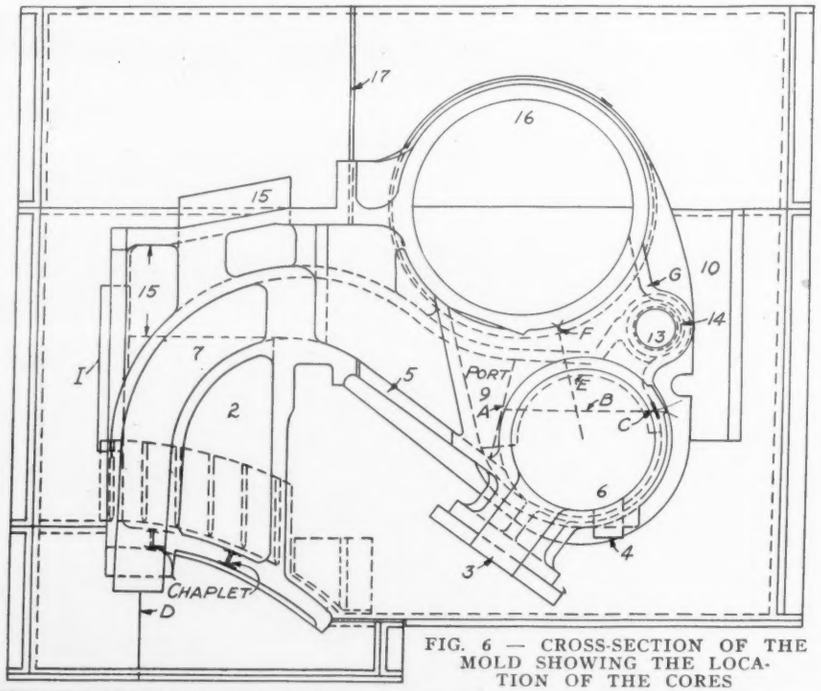


FIG. 6 — CROSS-SECTION OF THE MOLD SHOWING THE LOCATION OF THE CORES

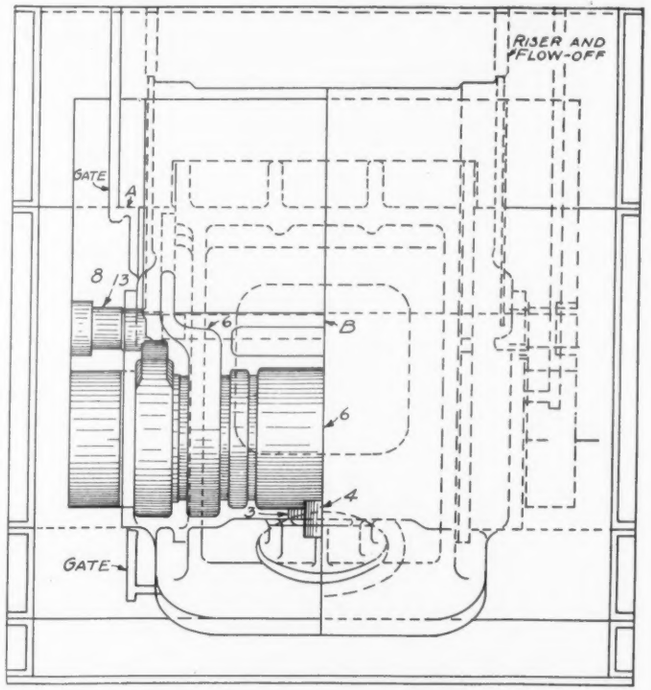


FIG. 5—SECTION OF MOLD SHOWING GATES AND RISERS, AS WELL AS LOCATION OF SOME OF THE MAIN CORES

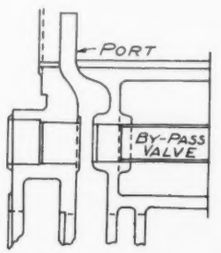


FIG. 7—SKETCH SHOWING THE PORT AND BY-PASS VALVE

shaken-out. The nuts are removed from the bolts on the outside of the flask, the bolts are driven in and the bars slide out of the flask with the cylinder casting.

Molding the Drag

The saddle or drag part of the pattern, shown in Fig. 8, and illustrated at *O*, Fig. 4, then is placed in position and sand is tucked and rammed around it. When the sand is rammed to a level of *DI*, Fig. 4, one of the bottom boards is placed in position and a parting is made extending from *I* to *J*. Drag flask *K*, Fig. 4, then is set over the cheek flask and is rammed with gate *L* in position as indicated. The bottom board covering the drag has a hole in it through which the gate *L* extends, thereby forming an opening through which the exhaust core is wired in place. After the bottom board is placed over the drag, the gate is drawn out and a pocket is formed at its end underneath the bottom board. After the bottom boards are secured, the cheek and drag are rolled-over.

Bolts and clamps are used for fastening together the different parts of the flask. The mold is vented somewhat, but not to the extent of that required for green sand. As a rule, the quicker the generated gases can escape from a mold, the sounder the casting. When an open sand is used for backing purposes, and with a limited thickness of sand between the flask and the pattern, the free escape of the gases is insured and not very much venting is required.

After the cheek and drag parts of the mold have been rolled-over, a parting is made and the cope section of the pattern, *I*, Fig. 8, is placed in position. The coreprint, *F*, Fig. 8, and the pattern then are covered with facing sand.

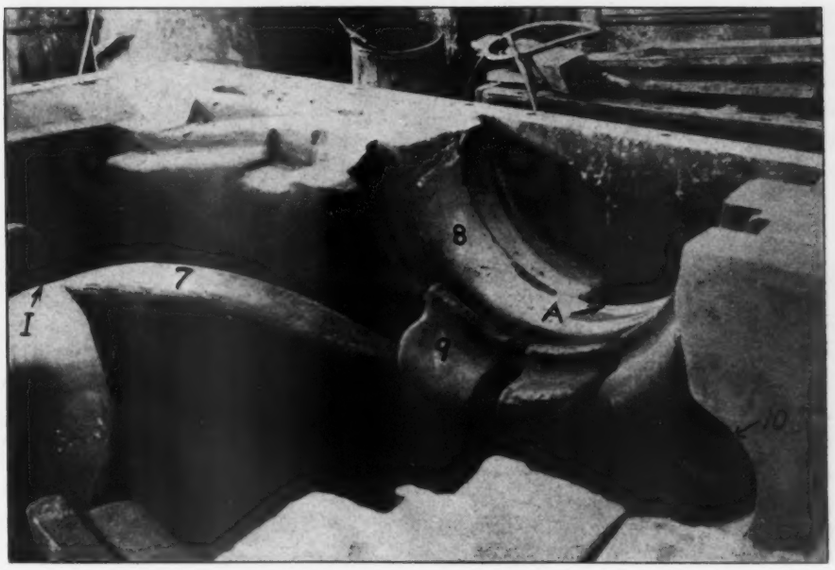


FIG. 9—CHEEK PART OF MOLD SHOWING MAIN BARREL PRINT

After setting the gate and placing the gaggers or hooks, the cope is rammed. The cope part of the mold then is lifted off, the cope pattern drawn and the coreprint and cope are finished. The cheek pattern is drawn next and parts of the mold are secured with nails. Loose piece *J*, Fig. 8, is drawn into the mold and removed, followed by drawing coreprints *B* and *M*, Fig. 8, and coreprint *P*, Fig. 4. These three prints are loose on the cheek pattern and remain in the sand when the main body pattern is drawn. The gates and sprues are drawn from the cheek and gates *A*, Fig. 5, are cut in the cheek. The mold is finished and is blacked while green and before drying.

The cheek then is lifted off the drag and the overhanging part of the mold over the saddle is finished. The saddle part of the pattern then is drawn from the drag. The pockets shown in the face of the saddle, indicated as the drag of the pattern, Fig. 8, were secured with spikes when the drag was rammed and this part of the mold consequently requires only a limited amount of repairing. Cores forming the bolt slots *I*, Fig. 1, are set before the cheek is blocked and returned and are bolted to the drag. The whole mold then is dried in an oven over night.

Setting the Cores

A large number of cores are set in the cheek and great care must be exercised in locating them properly. Dry compound is used as a binder for the heavy cores, but the port cores are made of a sand and flour mixture. The proper rodding and venting of the cores requires the attention of a skilled coremaker. The core forming the opening *I*, Fig. 3, is pasted and secured in print *I*, Fig. 6, and also is shown at *I*, Fig 9. Core *2*, Figs. 6 and 8, is set on chaplets. Cores *3* and *4*, Figs. 5 and 6, then are placed and form openings in the casting, as shown at *3* and *4*, Fig. 1. Core *5*, Fig. 6, forms opening *5*, Fig. 1. The piston valve core *6*, Figs. 5, 6 and 10, then is placed, followed by the exhaust core *7*, Figs. 6 and 9. This core forms a Y and each end of the Y extends into the piston valve core at the dotted line *A*, Fig. 6, being secured to the piston valve core by wire *B*, extending through piston core *6*, fastened at *C*. The joint between the cores is filled and dried. At the single end of the core, *D*, Fig. 6, a wire is extended down through the bottom board. Cores *8*, Figs. 5, 9 and 14, which form part of the outside of the cylinder between the piston and the barrel cores are set and fastened. The port cores *6*, Fig. 5, and *9*, Fig. 6, then are set in coreprints in the piston core *E*, Fig. 6.

The port cores *9*, Figs. 9 and 10,

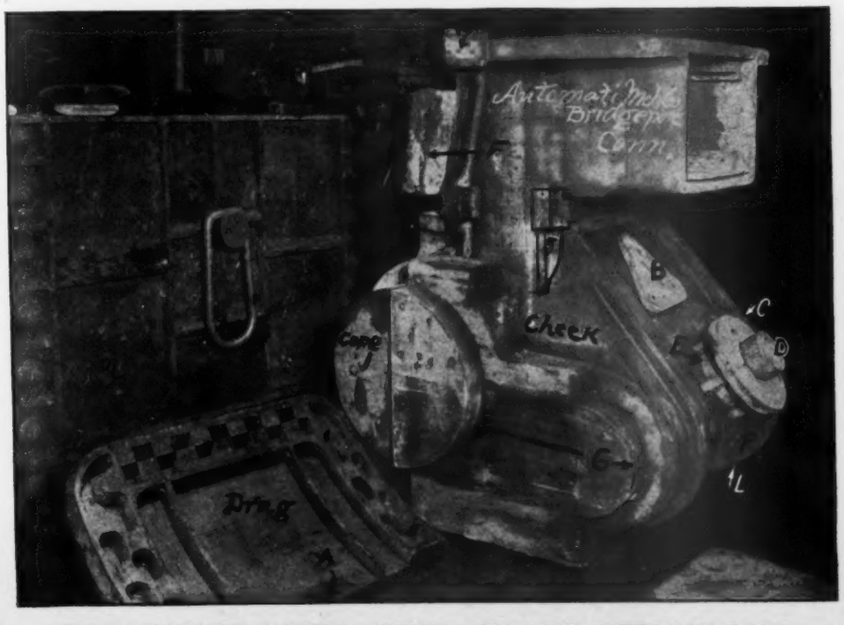


FIG. 8—CYLINDER PATTERN DIVIDED INTO COPE, CHEEK AND DRAG

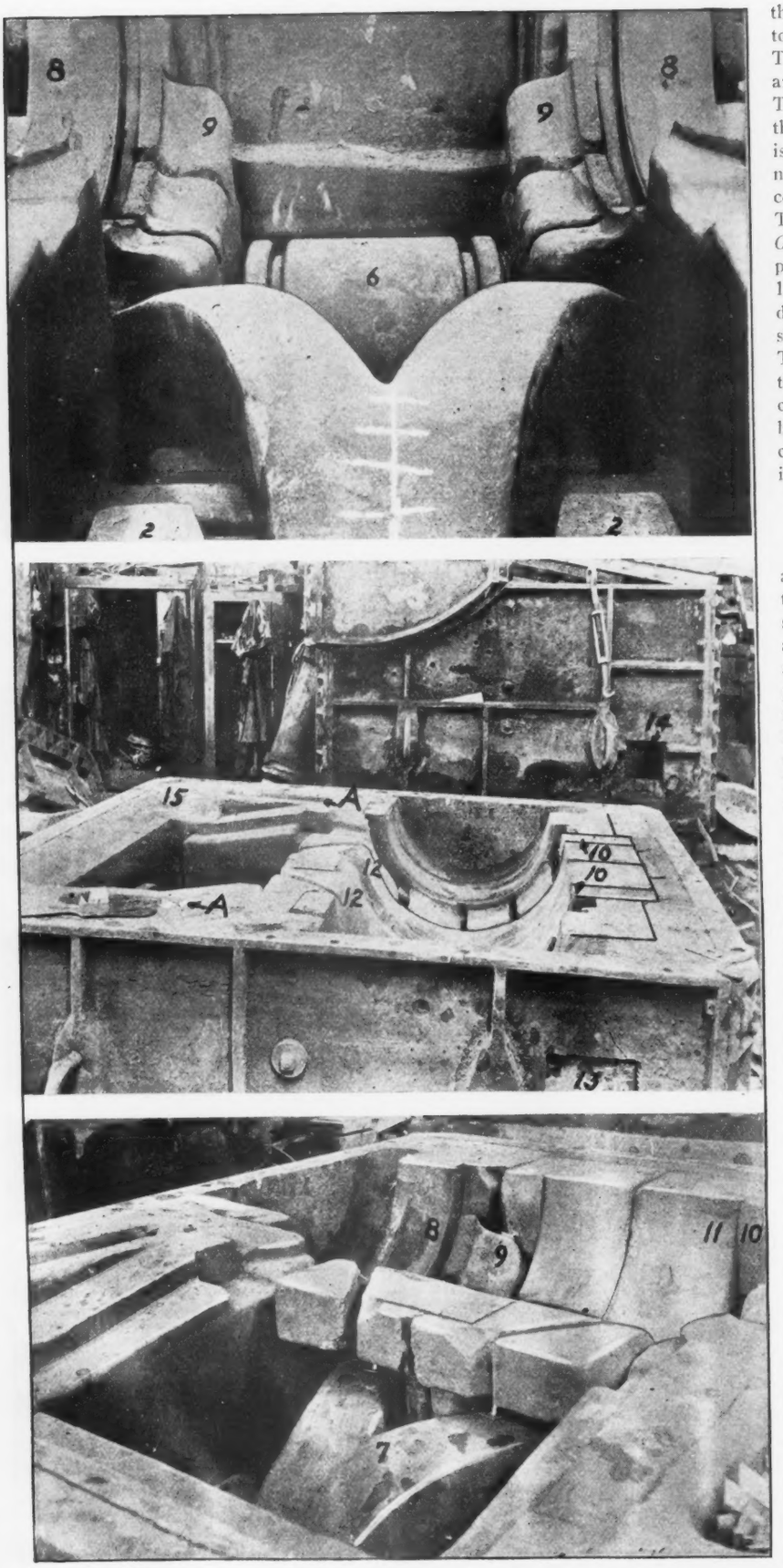


FIG. 10—PART OF THE MOLD, SHOWING PISTON VALVE CORE AT 6; FIG. 11—CORED CHEEK BEFORE BARREL CORE IS PLACED IN POSITION; FIG. 12—CHEEK PART OF MOLD, SHOWING Y-SHAPED EXHAUST CORE AT 7

then are set, pasted and are attached to the piston core by wires *F*, Fig. 6. The pockets formed at *C* and *F*, Fig. 6, are filled with sand, nailed and dried. The cheek and drag parts of the mold then are hoisted and the wire *D*, Fig. 6, is fastened. The cheek and drag are next lowered into the casting pit and cores *10*, Figs. 6, 11 and 12, are set. These cores form the wall thickness at *G*, Fig. 6, partly over the port and by-pass valve cores. Cores *12*, Figs. 11, 12 and 13, then are set and extend down between the opening in the Y-shaped exhaust core to core *5*, Fig. 6. These cores form part of the walls of the piston and the main barrels of the cylinder at the center, as they extend between the piston and the main barrel cores of the cylinder, forming the opening *A*, Fig. 2.

Setting Valve Cores

The by-pass valve cores *13*, Figs. 5 and 6, are placed in position by passing them through a square opening in the side of the cheek shown at *13*, Fig. 11, and in another flask in the background, at *14*. These by-pass valve cores are passed through opening *10*, Fig. 9, and meet in the center of the mold at *B*, Fig. 5. Great skill is required in setting these cores since the port cores are very light. The square opening in the flask through which these cores are passed, is covered with a plate and a rope extends through it to provide an outlet for the gas. The opening back of the core *A*, Fig. 9, then is filled and cores *15*, Fig. 11, forming notches in the flange *B*, Fig. 1, are pasted in place. Wherever possible, all joints between the cores are filled and nearly all the cores are pasted. The drying of the mold is completed by the use of an oil torch.

The core forming the inside of the cylinder, *15*, Figs. 6 and 13, and which cores out the openings *A* and *B*, Fig. 3, then is set in place. The vent from core *2*, Fig. 6, is brought up through this core and the gas from both escape at *A*, Fig. 13. The plate *B*, Fig. 13, contacts with a chaplet extending through the cope and holds down core *12* at this end of the mold. In Fig. 13, the main barrel core, *16*, is being lowered into the mold. After this core is set in position, the joint is prepared and the cope is tried on. The joint then is given its final preparation and the cope is closed and clamped.

Great care must be exercised to prevent the main barrel core of the cylinder from bearing on the port cores. If the barrel core contacts with the port cores at any point, they are liable to be cracked when the cope is secured. To avoid the possibility of this occurrence I prefer to have the port and bar-

rel cores separated by 3/32-inch. Also, the cope should not rest on the barrel core within 2 inches of the core iron *17*, Fig. 14. After the mold is clamped, the openings left at the ends of the main barrel core are rammed up and two heavy weights are placed across the cope, *17*, Fig. 6, to hold down the chaplets. The mold, weighted for pouring, is shown in Fig. 15 and in Fig. 14, the casting has just been shaken-out. In this view a large number of the adhering cores are illustrated.

Car Wheel Difficulties

Question:—We are experiencing some difficulty in making car wheels, 20 inches in diameter and which weigh 260 pounds. We would like to know the proper method of molding the wheels, whether face up or face down. How should they be gated and what depth of chill is required for wheels of this size?

Answer:—A chilled car wheel always is cast flange down, that is, with the flange in the drag. With a wheel molded in this way the dirt will gather in the edge of the rim, leaving only clean, solid metal in the flange. Clean treads are obtained by fast pouring and hot metal. The mold should be gated in the hub with two gates, one on each side of the center of the core. A pouring basin should be provided to receive the metal from the ladle and the metal should be poured so fast that it will accumulate in the basin. The gates also should be of ample size.

For a wheel 20 inches in diameter the chill should be about ⅜ inch in the throat, that is, between the flange and the tread. This would be indicated by a ¾-inch chill test. In other words, the depth of chill on a test piece, 1½ x 2½ inches, cast one edge against a chiller would be ¾-inch. The iron for a wheel of this size should analyze approximately as follows: Silicon, 0.80 to 1.00 per cent; manganese, 0.60 per cent; sulphur, 0.10 per cent, and phosphorus, as low as possible. This mixture can be obtained by using 50 per cent broken car wheels and 50 per cent pig iron, corresponding to No. 3 grade which should be used for a softener. These wheels must be thoroughly annealed in a pit lined with firebrick and they should be pitted as soon as possible after shaking-out. They are left in the pit for two or three days for cooling.

The Fulflo Pump Co., Cincinnati, now is located in its new plant at Blanchester, O., to which the main offices have been moved from Cincinnati.

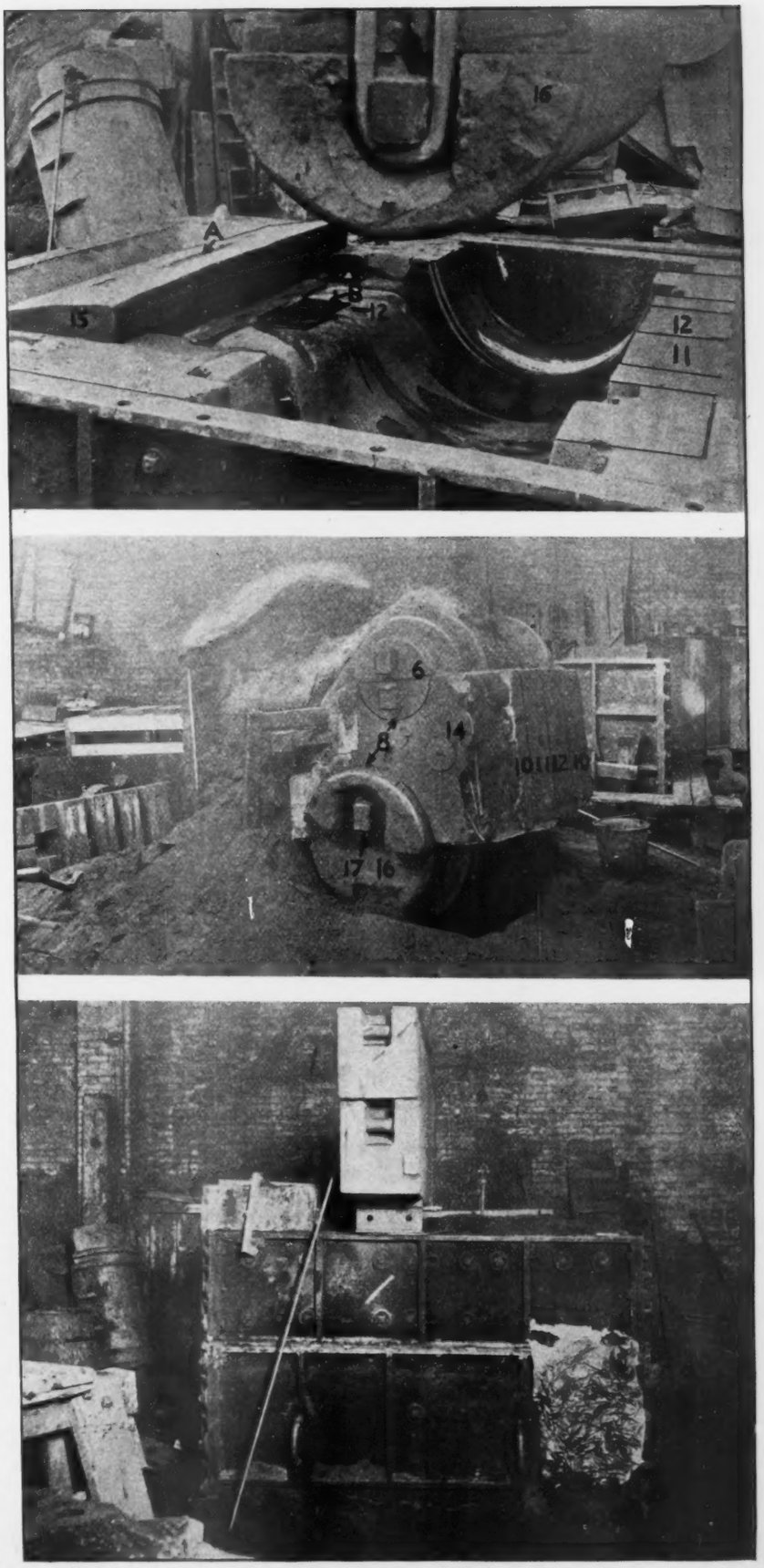


FIG. 13—LOWERING THE MAIN BARREL CORE INTO THE MOLD; FIG. 14—CYLINDER CASTING AS SHAKEN-OUT; FIG. 15—CYLINDER MOLD WEIGHTED FOR POURING

Estimating the Weights of Castings Rapidly

Several Easy Methods Are Presented Whereby Foundrymen May Quickly Ascertain the Weights From Blue Prints

By Warner Hathaway

FOUNDRYMEN today are obliged to quote prices on castings which allow only a small margin of profit, as competition is keen. To do this accurately they must know their foundry costs, cost of labor, overhead, etc., as well as the approximate weight of the casting to be produced, since the amount of metal entering into the casting is an important factor in the cost. When the patterns are furnished it is not difficult to estimate the weight, but as a rule foundries are asked to quote prices from the drawings. The methods of obtaining the weights of a casting from the drawing do not seem to be generally understood by foundrymen, the estimated weight being mostly guesswork. The methods for obtaining the weight from the drawing are simple and may be learned easily by careful study of the following instructions.

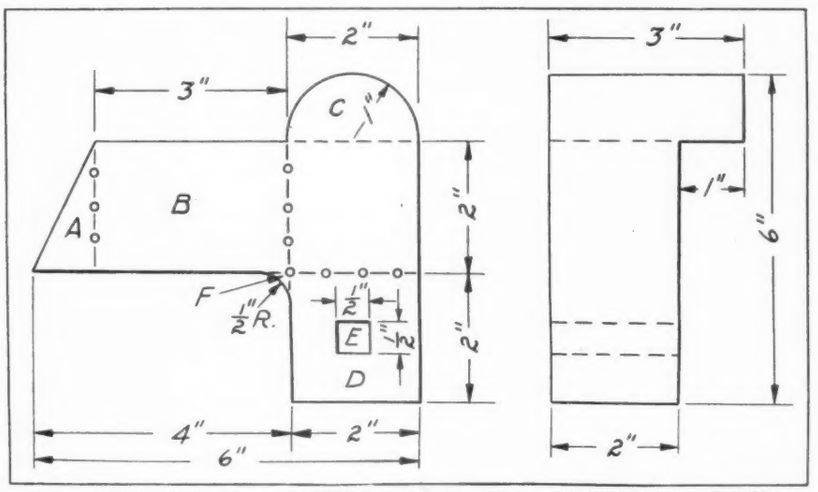


FIG. 1—DRAWING OF A CASTING DIVIDED INTO GEOMETRICAL FORMS FOR OBTAINING THE WEIGHT

The Mathematical Method

The mathematical method depends on dividing the drawing into various geometrical parts. The first step is to find the volume of iron, or other metal, contained in the casting. To do this the area of various cross-sections must be obtained and these multiplied by the length of the section. The various views of the casting are first divided into convenient geometric parts, for which rules for finding the areas are known. These cross-sections, together with the formulas for the area and volumes may be found by referring to Table I. If the area is figured in inches, the length must be in inches, and if in feet, the length must be in feet. From Table IV we may obtain the weight of a given cubic unit of any metal. Multiplying the cubical contents of the castings by the corresponding weight of a cubic unit of the metal in question, we obtain the weight of the casting.

Take, for example, the casting shown in Fig. 1. Let us assume that it is to be produced in cast iron and that it is necessary to estimate the weight to quote a piece price on the castings. The first step is to divide the front view into convenient geometrical figures, *A*, *B*, *C*, *D* and *E*. By reference to Table I the formula for each area may be obtained. Multiplying by the thickness of the metal, shown in the end view, the cubical contents can be obtained. The number of cubic inches in each unit is set down in order, as shown in Table III. The volumes of holes, etc., as *E*, which are to be deducted, are placed in Column II.

If the following calculations are followed and reference made to Table III the method will be clear. The cubical content is found to be 34.6733 cubic inches. One cubic inch of cast iron weighs 0.26041 pounds, therefore, the weight of the casting is equal to 34.6733 cubic inches multiplied by 0.26041 or 9.029 pounds.

To Obtain the Volume by Unit Ruled Paper

To obtain the area, rule a piece of tracing cloth into inch squares, each of which is divided into 100 small squares, or some other convenient number. Place the ruled section on the figure in question and count the number of small divisions inside the outline. Each small square represents one one-hundredth of a square inch. The total number of squares and half squares and fraction of squares when counted. will give the entire area. A piece of window screen may be used in the same way, first counting the number of meshes per square inch. Having obtained the area, multiply by the thickness of the metal. This will be the volume. The volume multiplied by the unit weight of the metal in question will give the weight of the casting.

To obtain the weight from a template select a piece of heavy paper of uniform thickness and cut out 1 square inch. Weigh this on a delicate balance, such as is used in making chemical analyses; obtain the weight as accurately as possible. Let us assume that the 1 inch square weighs 1 gram. Lay out the outline of the figure from the drawing of the casting, using the same

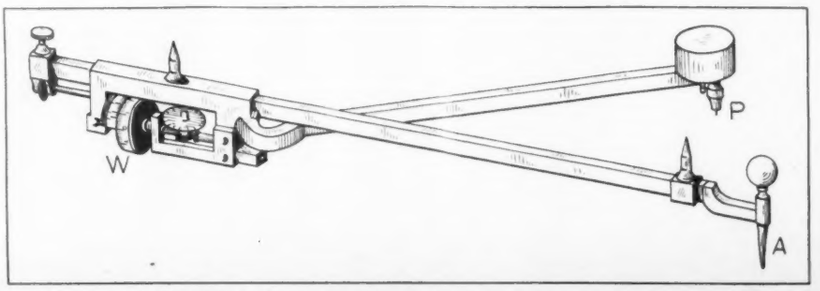


FIG. 2—PLANIMETER FOR DETERMINING THE AREA OF A FIGURE ON A DRAWING

TABLE I

Area and Volume of Various Solids

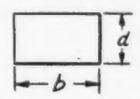
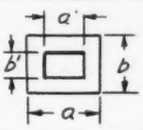
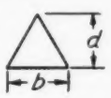
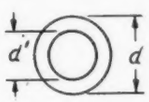
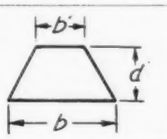
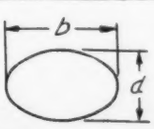
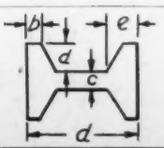
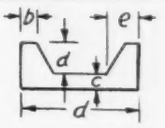
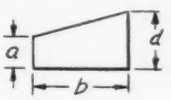
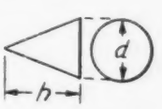
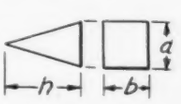
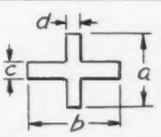
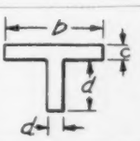
Section	Area	Volume
(1) 	$a \times b$	$(a \times b)\ L$
(2) 	$(a \times b) - (a^1 \times b^1)$	$L\ [(a \times b) - (a^1 \times b^1)]$
(3) 	$\frac{b \times d}{2}$	$\frac{b \times d \times L}{2}$
(4)	$0.7854\ d^2$	$0.7854\ d^2\ L$
(5) 	$0.7854\ (d^2 - d^{1\,2})$	$.7854\ L\ (d^2 - d^{1\,2})$
(6)	$0.393\ d^2$	$0.393\ d^2\ L$
(7) 	$\frac{(b + b^1)}{2} \times d$	$\frac{(b + b^1)}{2} L\ d$
(8)	$0.866\ d^2$	$0.866\ d^2 L$
(9)	$0.828\ d^2$	$0.828\ d^2\ L$
(10) 	$0.785\ b\ d$	$0.785\ d\ b\ L$
(11) 	$cd + 2a\ (b + e)$	$L\ [cd + 2a\ (b + e)]$

TABLE I—Continued

Area and Volume of Various Solids

Section	Area	Volume
(12) 	$cd + a\ (b + e)$	$[cd + a\ (b + e)]\ L$
(13)	$0.2146\ r^2$	$0.2146\ r^2\ L$
(14)	$0.3925\ (d^2 - d^{1\,2})$	$0.3925L\ (d^2 - d^{1\,2})$
(15) 	$\frac{(a + d)}{2}\ b$	$\frac{(a + d)}{2}\ b\ L$
(16)		$0.5236\ d^3$
(17) 		$0.2618\ d^3$
(18) 		$\frac{b\ d\ h}{3}$
(19)		$\frac{a\ b\ h}{6}$
(20) 	$da + c\ (b - d)$	$L\ [da + c\ (b - d)]$
(21) 	$b\ c + a\ d$	$(b\ c + ad)\ L$

quality of paper. Cut out this template and weigh it. Let us assume that this has been done and that the template weighs 20 grams. Since 1 square inch of paper weighed 1 gram, it must follow that the template contains 20 square inches. Therefore, the area in question contains 20 square inches. This multiplied by the thickness of the metal and the unit of weight, will give the required weight of the casting. The planimeter is an instrument used for determining the area of a figure on a drawing. Fig. 2 shows a planimeter of the polar type. The tracing point of the instrument, *A*, is moved along the outline of the area, following it in clock wise direction. One arm of the instrument is fixed to the paper by means of a point, *P*. When a complete circumference of the outline has been made, the area of the figure is read on the wheel, *W*. Having the area of the figure it is only necessary to proceed as in the other cases to obtain the weight of the casting. A polar planimeter may be found in almost any well equipped drawing room. One may be purchased for about $20 and will soon pay for itself, as it is a rapid and accurate method of obtaining areas when drawings are made to scale.

Accuracy is Essential

In estimating weights by any of the foregoing methods, care should be taken to make deductions for all holes and other openings. Small, curved sections, such as fillets, should not be neglected for they contain much weight. It must also be remembered that castings will strain somewhat, as a general rule being slightly heavier in various sections than the pattern. Accuracy of calculations is important as a small error may greatly affect the price.

Table II

Example for Obtaining the Volume of Different Forms

Vol. A—See Form (3) Table I
d = 2″, b = 4″ — 3″ = 1″
L = 2″
$$\text{Vol. A} = \frac{b \times d \times L}{2} = \frac{1 \times 2 \times 2}{2} = 2 \text{ cu. in.}$$
Vol. B—See Form (1) Table I
a = 2″, b = 3 + 2 = 5″
L = 2″
Vol. B = a × b × L = 2 × 5 × 2 = 20 cu. in.
Vol. C—See Form (6) Table I
d = 2″, L = 3″
Vol. C = 0.393 d^2 L
= 0.393 × 2 × 2 × 3 = 4.616 cu. in.
Vol. D—See Form (1) Table I
a = 2″, b = 2″, L = 2″
Vol. D = a × b × L = 2 × 2 × 2 = 8 cu. in.
Vol. E—See Form (1) Table I
a = ½″, b = ½″, L = 2″
Vol. E = a × b × L = ½ × ½ × 2 = ½ cu. in.
Vol. F—See Form (13) Table I
R = ½″, L = 2″
Vol. F = 0.2146 r^2L
= 0.2146 × ½ × ½ × 2 = 0.1073 cu. in.

Machine Facilitates the Chilling of Castings

A process patented in England for producing chill castings of iron, copper, nickel and aluminum, employs a machine, so designed, that the molds are subjected to a sustained blow, just as the metal begins to solidify. The movement is similar to that produced by a jar-ramming machine, and the effects on the alloy are claimed to result in a great improvement of its physical properties of toughness, tenacity, impermeability and homogeneity. It is claimed that the crystals, at the moment of formation, are packed together or shrunk by the shock, into closely locked and intertwined relation. In the case of iron, the castings are ejected from the molds, with sufficient rapidity to avoid chilling. A copper-zinc alloy, with substantially 40 per cent zinc, is so improved in physical properties by this treatment, that its tensile strength, it is stated, is increased from 42,000 to 54,000 and 73,000 pounds per square inch, while the elongation is increased from about 15 to from 40 to 60 per cent.

How Drawings Influence Shop Efficiency

By M. E. Duggan

In a paper read recently before a technical society, the author states, "Few managers realize the unnecessary expense and delay in production that are caused in the pattern department by not having it in closer touch with the drafting room and the foundry. In the first place, too little consideration is given in the drafting room to the design of machine parts that are to be cast." The writer surely does not expect a draftsman who does not understand patternmaking and foundry practice to be able to solve shop problems. The shop manager is asking the impossible who expects drawings of machine parts and mechanical details which can be made at a minimum cost from draftsman with little or no practical experience. I started 35 years ago, as an apprentice, to learn the patternmaking trade. I can well remember even in that early day the kicks that came from all quarters about excessive pattern costs, and I have been listening to them ever since. The blame for these excessive costs does not always rest on the patternmaker. Suppose you have to meet a number of new conditions. a part for which a pattern is desired The job starts in the drafting room, where a drawing is made showing filleted angles, rounded corners and curves of all kinds wherever theory seems to demand them. Next a tracing is made, and finally a blue print for the patternmaker. By the time the job reaches the pattern shop, some one becomes impatient, and the patternmaker is told to rush the work. Three or four days have been lost in making drawings, tracings, blue prints, etc., and the final result sometimes hinders rather than aids the experienced patternmaker who is thoroughly familiar with foundry practice.

If a few free-hand sketches and dimensions are given the patternmaker in the beginning, together with any necessary instructions as to details, the patterns will be finished by the time the blue print stage is reached in the drafting room. In addition the patternmaker will avoid unnecessary time, labor and expense in making the pattern. If your drawing calls for unnecessary work that requires labor and time, don't kick. You get what the drawing calls for.

Table III

Method of Estimating the Weight of the Casting, Fig. 1

Vol.	Sec. Table I	Col. I Vol., cu. in.	Col. II Vol., cu. in. to be deducted from Col. I
A	3	2.00	....
B	1	20.00	....
C	6	4.616	....
D	1	8.00	....
E	1	....	0.05
F	13	0.1073	....
Sum		34.7233	0.05
		0.05	
Total cu. in..		34.6733	

Wt. 1 cu. in cast iron = 0.26041 lbs.
Wt. of casting Fig. I = 34.6733 x 0.26041 = 9.029 lbs.

Table IV

Table of Weights of Metals

Metal	Weight per cubic foot, pounds	Weight per cubic inch, pounds
Aluminum	166.5	0.0963
Brass, yellow	525.0	0.30381
Bronze	552.0	0.3195
Copper	552.0	0.3195
Iron, cast	450.0	0.26041
Lead	709.7	0.4106
Steel, cast	489.6	0.2834
Tin	458.3	0.2652
White metal	670.3	0.3879
Zinc	436.5	0.2526

What is the Matter With My Nickel Solution?

Many of the Difficulties of the Plates Are Considered and Some Remedies Are Presented That Will Solve Many Perplexing Problems

By E P Later

A NUMBER of requests for information regarding nickel solutions, generally couched in more or less despairing terms, recently have been addressed to me by platers in different parts of the country. In a general way, most of these appeals are similar in many details. It is usually stated that the solution, after working satisfactorily for some time, begins to produce work that peels off, or is spotted, or pitted, or any one of several things it should not be; then follows a recital of what has been done to combat the trouble, needless to say none of these remedial measures has affected a cure, together with a list of data regarding the conditions, which the plater evidently thinks will be of help in diagnosing the difficulty.

Sometimes the cause of the trouble is apparent at once; in other cases it is not so easy to point out what is wrong and a little investigation may be required before everything is cleared up. One of the most interesting aspects of such requests, however, is the insight which the plater unconsciously gives of his ability in and knowledge of his chosen profession. Much of the data volunteered at such times are quite irrelevant or, if the information has any bearing on the subject, it either is incomplete or is stated in such ambiguous terms that it is of doubtful value.

Elements of Nickel Plating Considered

For the benefit of those who may be having trouble with their nickel baths—although a good part of the discussion which follows will apply to plating solutions other than nickel—it may be helpful and interesting to consider some of the more common defects in plated work and the causes which underlie their production. Before going any further, however, it may save confusion and lead to a clearer understanding of the subject if the mechanism of plating is hastily reviewed.

In its simplest, and incidentally its best form, a nickel plating bath consists of a water solution containing a certain quantity of nickel salts; a small amount of boric acid and preferably some chlorine in the form of magnesium chloride, or nickel chloride to assist in producing a more vigorous anode attack. It is, or should be, a matter of common knowledge among platers that when nickel and other metallic salts are dissolved in water they undergo a sort of decomposition whereby the metal, nickel in this case, takes the form of exceedingly minute particles known as *ions*, each of which carries a charge of positive electricity; the acid part of the salt, the sulphate radical as it is called, carries a charge of negative electricity. For the purpose of distinguishing between the *ions* they are called *cat-ions* or *an-ions*, or simply *positive ions* and *negative ions*.

How the Ions Line Up

So long as no current is passed through the solution the ions wander aimlessly around, being diffused uniformly throughout the whole bulk of the solution. As soon as a current is sent through, however, a great, although to us invisible, change takes place. As soldiers obeying a command the ions line up, as it were, and proceed to make their way to either the anode or cathode, depending on whether they, the ions, bear negative or positive charges. Thus, the positive nickel ions go to the negatively charged cathode, the parts to be finished, and plate out in metallic form. At the same time the acid or negative radicals are attracted to the positive pole—the anode; this is attacked by them with the result that a certain amount of metal is dissolved and taken into the bath thereby replacing, to a greater or lesser degree, the nickel which has been removed from the solution and deposited on the plated parts.

There is contained much of the secret of the successful operation of nickel baths; other things being equal, the more nearly the replenishment of the solution with nickel dissolved from the anodes matches the amount of nickel deposited on the work, the better will be the performance of the bath all around. And this is the point where many platers go astray.

Nickel Bath Impoverished

Normally, the metal dissolved from the anodes is somewhat less than the amount deposited on the cathode, with the result that the bath suffers a continuous and more or less rapid impoverishment in metal; this must be made up by the addition, from time to time, of nickel salts. The metal content of a plating bath is an item of the utmost importance; therefore, if these additions are not made at sufficiently frequent intervals or in sufficient amounts, trouble may be expected to develop, which will manifest itself in the production of inferior work.

Again, we sometimes lose sight of the fact that the effective anode surface of a tank consistently is growing smaller while the bath is in use by reason of the slow but steady solution of the metal. But as the anodes grow smaller, less surface is exposed to attack and the amount of metal taken into solution gradually diminishes. Unless some means of accurately determining the amount of metal present are employed, the net result is that the metal content of the bath is reduced to the point where difficulty is experienced in producing satisfactory work.

Anodes Practically Worthless

A case of this sort came to my attention not long ago. A plater had found by experience and rough tests that the addition of a certain amount of nickel salts to his bath each week would keep it in good working order. All went well for a considerable length of time, but eventually trouble began to be encountered and efforts were made to find the cause of the difficulty. The diagnosis of too low metal content was easily shown to be correct by actual determination of the amount of nickel in solution, but the plater stoutly maintained that he had been adding the same amount of nickel salts right along and was unable to understand why the solution should be low in metal.

Upon examination the anodes were found to be reduced to a fraction of their former size and were spongy and soft in places, showing that practically all of the nickel had been dissolved out. The consequence was, of course, that the bath was being replenished almost entirely from the salts added, and the amount of these was not sufficient to make up fully for the metal taken out on the work. A sufficient number of new anodes to give an effective surface area

slightly greater than that of the usual load of work were added, together with enough nickel salts to build the bath up to normal, and no further trouble was encountered.

All of this brings up prominently the question of the proper maintenance of plating baths, and while this subject has been treated in some detail in previous issues of THE FOUNDRY, it is so important and has such a bearing on the subject of this article that a few suggestions may not be out of place. When a bath is properly made up and in working order, the problem is to keep it that way and the measure of success attained in this endeavor, to a certain degree, is the measure of the plater's skill and ability.

Testing for Metals in Solution

Some platers rely almost exclusively on the hydrometer to give them all necessary information about the condition or composition of their solutions. Now, as a quick and ready means of determining the density of any liquid the hydrometer has much to recommend it, and when used with a full understanding of its limitations, it is of undoubted value. In effect, however, the mistake is frequently made of considering that the reading which it gives is a direct measure of the amount of nickel or other metal actually present. Such a view contains just enough truth and falsehood to make it dangerous, if followed too implicitly. It is true that the density of a nickel bath may be increased by the addition of more salts, but the addition of any other soluble salts will do the same thing. The reading which we obtain, then, when a hydrometer is placed in a plating bath is a measure of the combined effect of all of the substances which are in solution, not of the nickel salts alone.

Something of this sort develepod recently. An old nickel bath was behaving badly and the plater was unable to determine the cause. The indications seemed to point to a low nickel content, but a suggestion to this effect elicited the positive statement that this could not be the case. Salts were added occasionally and, in addition, the hydrometer showed that the bath was of apparently satisfactory density. Estimation of the nickel by chemical means disclosed that it was far below what it should have been. Further investigation, together with some careful questioning soon showed that conducting salts, brighteners and all sorts of things, for some time had been added in profusion in the effort to overcome certain objectionable features of the deposit. The inevitable result was that in time the bath became loaded up with enough salts of various kinds to give a high reading on the hydrometer, although in reality the nickel actually present, the one indispensable thing, was much less than it should have been.

The point of all this is that the hydrometer, used in connection with chemical control of the solution, through actual determination of the metal content, has a certain field of usefulness, and when intelligently employed, may be of considerable assistance, but it is not advisable to depend on it entirely. The estimation of the nickel present is not a long nor a difficult matter and the apparatus required is simple and comparatively inexpensive. The results, on the other hand, have a value out of all proportion to the time and expense necessary to obtain them.

In the consideration of some of the defects which are found in nickel-plated work, it may be said that pitting is one of the commonest of these. As every plater knows, it manifests itself in the form of numerous small depressions or specks; frequently there is a sort of tail or mark on one side of these in the deposited nickel and it is an unsightly and objectionable condition. It is occasioned by the formation of gas bubbles on the parts during the plating operation, and this in turn usually is caused by too much free acid, too low metal content or too high current.

One point to be borne in mine in connection with the operation of nickel baths is that they should be kept only very slightly acid. The presence of acid in any quantity results in the deposition of hydrogen gas along with the nickel; hydrogen, it must be remembered, acts exactly like a metal, under many circumstances. When a bubble forms on a surface during plating it prevents, to a greater or lesser degree, the deposition of any nickel immediately underneath it and thus there is produced a small, depressed spot in which the nickel is thinner than on the adjoining surfaces.

Detecting Acidity of Bath

Acidity in a nickel bath may be detected by the use of litmus paper or other indicator, and when necessary may be corrected by the cautious addition of ammonia water or nickel carbonate. The latter is perhaps preferable to the former, inasmuch as by its addition the bath is built up in metal content at the same time as the acid is neutralized. There is the further consideration also that the bath is not loaded up thereby with inert salts; moreover, an excess of ammonium salts in a solution tends to darken the deposit. One way of adding the carbonate is to suspend cloth bags filled with in the bath. This can be done conveniently at night and the acid allowed to attack the carbonate and slowly take it into solution. When the acid is all neutralized the action stops and no more metal goes into the bath, since the nickel carbonate is not soluble in water alone.

Too low metal content is a rather frequent cause of pitting and the action is somewhat as indicated in the foregoing. When the amount of nickel falls below a certain point, hydrogen begins to deposit out along with the metal and a defective coating results.

Metal Facilitates Current Passage

It may be remarked, incidentally, that the metal content of a solution is a feature of the utmost importance in determining the maximum permissible current consistent with satisfactory results. The more metal there is in solution the greater are the facilities afforded for the passage of the current, by reason of the increased number of ions, and consequently, a heavier current can be safely transported from the anode to the cathode. The old-time baths, with only a small amount of nickel in solution, could not be operated at more than a very few amperes per square foot, but in a previous article I described the preparation of certain solutions which can be worked at several hundred amperes per square foot. Fifteen to 20 amperes per square foot, and above, are used in many establishments and thoroughly satisfactory work turned out in a fraction of the time formerly required. The secret about such baths, if there is any secret about them, is simply that they are comparatively highly concentrated; they have a large amount of metal in solution.

The up-to-date plater will, therefore, see to it that his metal content does not fall below a certain amount; the exact figure will depend on the composition of the bath which experience has shown to give the best results for the class of work being finished, not alone for the sake of preventing trouble from pitting, although is a justifiable end in itself, but also for the speed with which the work can be turned out.

There is no economy in trying to economize on nickel salts and anodes, even though these do cost more now. The most that can be done by such tactics is to postpone their purchase for a time, while the time and labor wasted in turning out inferior work,

with the resultant higher percentage of rejections, will eat deeply into the profits.

Another defect which resembles pitting and is sometimes mistaken for it, shows itself as small holes in the coating or roughness of the surface. It is occasioned by tiny particles floating in the solution, attaching themselves, in one way or another to the surface of the parts. Obviously, the remedy is to keep the bath as clean and free from such particles as possible and it should be filtered at sufficiently frequent intervals.

Peeling of the Nickel Coating

Peeling of the coating is another annoying defect which sometimes develops. There are two principal causes for this condition—absorption of hydrogen, generated through the use of too high current, or too much acid in the bath and imperfect cleaning. When hydrogen is absorbed by a nickel deposit it tends to make the latter much harder and more brittle than usual, so much so, in fact, that instead of clinging firmly to the underlying metal, it tears itself loose, sometimes over an area of considerable extent. The remedy in such cases is evident—reduce the acidity to the proper degree. If this does not clear up the trouble it may well be that too strong a current is being used which, in the light of what has been said, is sometimes only another way of expressing the fact that the metal content of the bath is too low. This is on the assumption, of course, that the current passed through the tank is not materially greater than has been used previously for substantially the same number of square feet of cathode surface. In this event, raising the amount of metal in solution to the figure called for by the original formula, or even higher, will usually put an end to the difficulty.

Lack of adherence on the part of the coating due to imperfect cleaning is not entirely unknown and the subject of cleaning is of sufficient importance to warrant careful study, inasmuch as a good deal depends on the thoroughness with which this part of the plater's work is done. Unless every trace of grease is removed from the surface of the work, the deposit cannot adhere to it with the firmness necessary to prevent loosening.

The parts which come to the plating room usually are covered with some sort of an oily or greasy film; the exact nature of the material composing this will depend to some extent on the purpose for which it was applied. For example, the objects to be plated may be coated with a heavy mineral oil or vaseline, as a protection against rust, or covered with the lubricants employed in drawing or machining operations; or, again, with the thin film of grease remaining from the buffing operation.

One of the distinguishing characteristics between oils and greases of animal origin, as opposed to mineral oils, is that of their behavior toward caustic alkalis. The former are decomposed chemically by the strong alkali forming a soap, by a process known as saponification and by setting glycerine free; both of these substances are soluble in water, whereas the original oil or grease was not. The customary practice of cleaning parts by immersing them in a hot solution of some alkali, when properly carried out, is effective when the grease film is of such a character that it can be broken up in this way.

Suggestions for Cleaning

In this connection, however, one or two points may be mentioned which are deserving of care. It is apparent that the cleaning solution grows constantly weaker through use, inasmuch as the alkali in it is actually used up in combining with the oil or grease; therefore, the solution must be kept up to good working strength by the periodic addition of fresh material, if quick and thorough cleaning is to be accomplished. Another point is that parts which are heavily coated with grease may be cleaned to better advantage in every way by brushing them off once or twice while they are in the tank or even by rinsing them in clean, boiling water and then returning them to the cleaning solution again. The reason for this is that some of the soap or other foreign matter, may cling tenaciously to the surface of the parts and thus retard the action of the alkali. There usually is more or less staining of the surface of parts which have been cleaned in strongly alkaline solutions, and this ordinarily is removed by immersion for a moment in a cyanide solution.

It must not be supposed from the foregoing that mineral oils or greases are not affected by immersion in the ordinary cleaning solutions, for while it is true that these cannot be saponified, such treatment does emulsify and remove them to some extent. Ordinarily, however, other methods must be resorted to in order to produce the requisite cleaning.

One quick and effective way of going about this is to dip the parts in gasoline ,thereby removing the great bulk of the coating by simple solution. Of course, something of this sort must be done in the case of parts composed of metals which are attacked by strong alkalis; aluminum and zinc, for example, are easily dissolved by these. This treatment then may be followed by immersion in the regular alkaline cleaner, in the case of parts which permit of this and, if necessary, further supplemented by scrubbing with very fine pumice stone or whiting mixed with water, the latter to be used on parts which have highly polished surfaces. A light dip also is quite effective in removing the last traces of grease from parts which can be given this treatment.

The electric cleaner likewise offers a good means of quickly cleaning the parts before plating, regardless of the character of the oily film to be removed. The action in this case to a great extent is mechanical, the large amount of gas given off from the surface of the parts helping to loosen and carry away any foreign matter.

The foregoing are by no means the only defects which nickel plated work may develop, but they are ordinarily the most troublesome. One other will be considered, namely, a deposit with a yellowish tinge. This is due to an alkaline condition of the bath and may be corrected by the addition of sulphuric acid.

Asbestos Used to Prevent Stools from Burning Onto Crucibles

By H. B. Maxwell

In the April issue of THE FOUNDRY, page 168, is published an inquiry and a reply on the subject of preventing stools from burning onto crucibles. It is stated that it is a question of temperature and that if the temperature is sufficiently high that the crucible will free itself from the stool. We have had experience both with coke and oil-fired furnaces and always have found that when the stool was hot enough to string like molasses candy, that it still adhered to the crucible like a long-lost brother who needs financial assistance. We have never experienced any success in the use of powdered coke to prevent the crucible from adhering to the stool. However, powdered asbestos serves the purpose and a thin layer of this material placed on the stool will prevent all further difficulty.

The Welland plant of the Canadian Steel Foundries, Ltd., produced 6788 tons of basic open-hearth steel in 26 working days during the month of March. The steel was melted in four furnaces of 20 tons capacity and a large percentage of turnings was charged. Throughout the month no part of a heat was lost from any cause.

Molding and Casting Ornamental Bronze Tablets

The Difficulties Confronting the Molder Are Pointed Out in Detail and Mixtures for These Castings Are Included

By Charles Vickers

MORE than ordinary skill is required for the production of ornamental bronze tablets. If the tablet has undercut figures special molding methods must be applied. The figures on most tablets made at the present time, however, have normal draft which simplifies the molding problem. The location of the gates must be given careful consideration, especially if the tablet is a large one. Good judgment also is required to estimate correctly the number of pouring sprues necessary to produce a sharp casting free from strains. In addition, the composition of the metal must be satisfactory. It should be free from iron, must be melted with a minimum of oxidation and poured at the correct temperature. The mold and the metal share equally the responsibility for a successful result, for if the mold is not made properly the casting will be unsatisfactory regardless of the quality of the metal; on the other hand, if the metal is not right, the most skillful molding conceivable will not save the situation.

The tablets shown in Fig. 1 are attached to the soldiers' monument in the court house square at Peoria, Ill. These tablets contain an aggregate of 683 names. The letters are very deeply cut. The long narrow tablet reading "Volunteer Soldiers of Peoria County and Vicinity Who Fell in Battle or Lost Their Lives in the Service" is 7 feet 11 inches long. The individual tablets immediately underneath have a total length of 14 feet 8 inches. The lower row of tablets is 11 feet in length. The uppermost tablet in Fig. 1 was cast in one piece. The tablets in the two lower rows were cast in sections. Those in the middle row are 11 inches wide and 18 inches high, while those in the lower row have the same width and a height of 12½ inches.

Fig. 2 shows a tablet containing Lincoln's Gettysburg address which was recently placed on a new high school at Peoria, Ill. This tablet is 4 feet wide and 3 feet 8 inches in height. It is an excellent example of ornamental bronze tablet work and was designed, cast and finished entirely in the city of Peoria. The pattern and the casting, as well as those for the tablets shown in Fig. 1, were made by the Brass Foundry Co., Peoria. In executing this work an ingenious method of ramming the molds was devised.

How Ramming Difficulties Are Overcome

A very annoying difficulty arises in ramming molds for such castings as tablets, name plates and other flat pieces containing letters or figures raised above a background. In shop parlance this difficulty is termed ramming-away. It may be defined as the spreading of the face of the mold next to the pattern after the facing sand has been tucked and while the backing sand is being rammed into the flask. Ramming-away may occur in either the cope or the drag, but it is more likely to happen in the latter where there are no bars to retain the sand. Ramming-away may be local or general. In other words, only a small part of the inscription may be rammed-away or the whole face of the mold may have shifted. A molder usually tries to correct local ramming-away by patching the figures or letters. This generally results in a rough casting. In the case of a general ram-away, the only cure is to shake-out and start over again. Ramming-away does not reveal itself until the last stages of the work after the mold is rammed, the cope lifted and the pattern drawn. Often at this stage of the process the metal is ready or nearly so. It will be readily understood, therefore, that the difficulty is a serious one.

As previously suggested, ramming-away is caused by a sliding of the sand next to the face of the mold after it has taken the impression of the pattern. As the raised letters or figures on the pattern are fixed, the sand moves away from them 1/16 to ⅛-inch on one side and crushes up against the opposite side. Therefore, when the pattern is drawn the letters may be twice as thick as they should be. In addition the sand that has moved away is more or less crumbled. The molder sometimes tries to save the job by ramming the cope over again. A drop-out is frequently the result. As previously suggested, the only thing to do after a mold has rammed-away is to start over again and remold both the cope and the drag entirely anew. Ramming-away is the result either of lack of skill or carelessness on the part of the workman. It occurs when the molder neglects to wedge the sand on the face of the pattern immovably in place by ram-

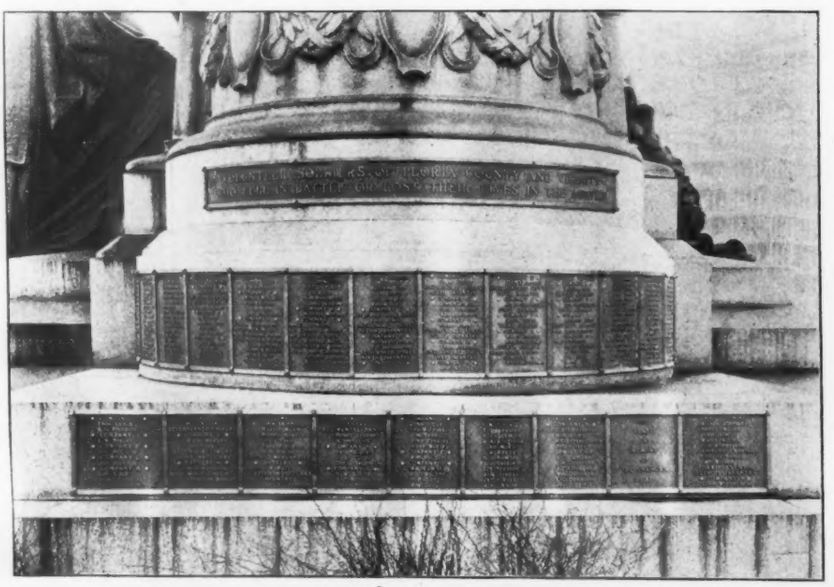


FIG. 1—BRONZE TABLETS ON BASE OF SOLDIERS' MONUMENT IN COURT HOUSE SQUARE, PEORIA, ILL.

ming it tightly between the outer edges of the pattern and the sides of the flask.

When ramming a tablet or name plate it is advisable, before tucking the sand over the pattern, to shovel riddled sand in between the edges of the pattern and the sides of the flask and ram it firmly to a considerable height above the pattern. When this has been done, the sand can be tucked lightly over the pattern commencing at the edges nearest the sides of the flask and working toward the center, encircling the mold.

No movement of the sand surface is possible because it is banked up by firmly packed sand that reaches to the sides of the flask. About 1 inch of sand should be placed over the face of the pattern during the preliminary ramming. After the entire surface has been gone over more sand can be added and the ramming completed in the ordinary manner.

Sand Quality Important

A good grade of molding sand should be employed. For the castings shown in Figs. 1 and 2 the sand was tempered the night before in order to have it in the proper mellow condition for molding. Instead of being rammed in the ordinary way the sand was dropped into the flask from an elevation of 10 feet. A suitable platform was erected for this purpose. The sand was sieved first through a very fine riddle and sprinkled over the face of the pattern. The body of the flask was filled up by screening the sand through a coarser riddle. By this method of ramming all danger of ramming-away was avoided.

The mold was provided with a number of gates in order to use simultaneously as many pouring pots as possible. J. G. Kasjens, president of the Brass Foundry Co., states that the work should be so arranged that each pot full of metal covers a definite area in the mold. The boundaries of this area should be determined accurately in order to produce a good casting. If the metal poured into the mold from one pot does not mix thoroughly with that coming from a neighboring pot, a cold shut or a misrun is sure to result.

It is a mistake to place gates all around the circumference of a large flat piece and pour strongly from a number of pots in the hope that the metal will shoot across toward the center of the mold before it cools. Usually, in this case, most of the force of the stream from each pot is neutralized by its neighbor with the result that the outer edge of the casting is badly strained while the center is a network. This can be avoided by dividing the surface of the pattern into squares proportionate to the running capacity of each pot of metal. Then each square should be provided with a drop or finger gate into which the molten metal can be poured from the individual pots. Several gates if desired can be connected to a runner basin and fewer pots used.

Various metal mixtures are employed for casting bronze tablets. One of the most satisfactory mixtures is made up as follows: Copper, 90 per cent; zinc, 7.5 per cent, and tin, 2.5 per cent. Another mixture that runs well and has a good color consists of 89.5 per cent copper, 5 per cent tin, 5 per cent zinc and 0.5 per cent lead. The copper should be melted under a cover of granular charcoal with a little salt and borax. When in a fluid condition, the white metals are added and the whole mixture is stirred thoroughly. The metal will have to be fluid and hot in order to run ornamental tablets successfully.

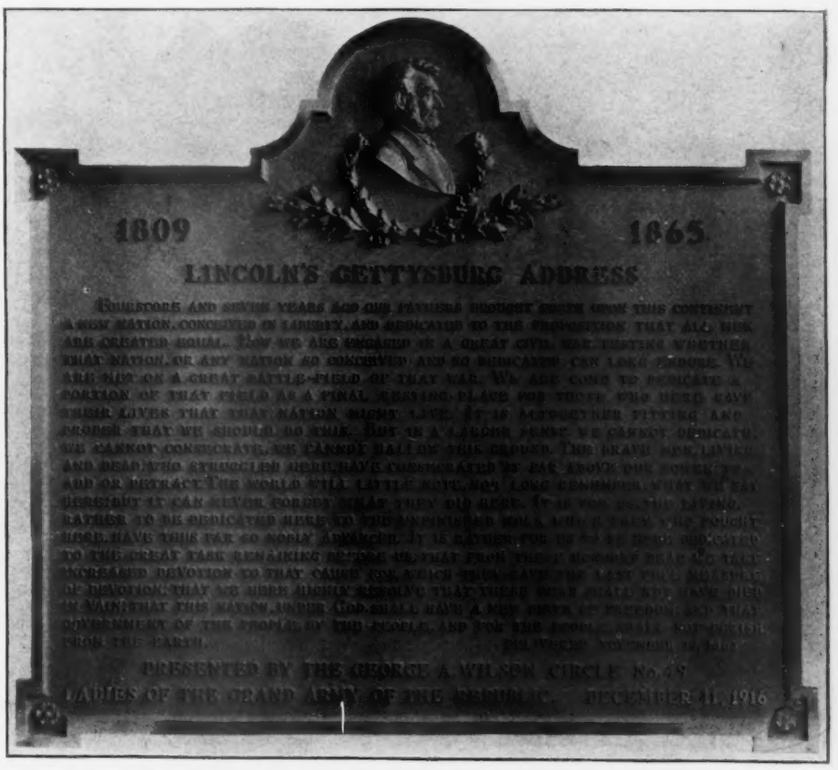


FIG. 2—TABLET CONTAINING LINCOLN'S GETTYSBURG ADDRESS

The Industrial Electric Furnace Co., Chicago, builder of the Snyder furnace, has shipped a unit of 1250 pounds capacity, designed for steel foundry work, together with auxiliary equipment, to Burn & Co., Calcutta, India. This company operates one of the largest iron and steel foundries in the Far East. The purchase was made by A. Anderson, American representative of Burn & Co.

Institute of Metals to Merge With Mining Engineers

A letter ballot of the members of the American Institute of Metals now is being taken on the merger of this organization with the American Institute of Mining Engineers. When consolidated the Metals institute will be known as the Institute of Metals division of this society. The proposed union has been favorably acted upon by the executive board of the American Institute of Metals and the board of the American Institute of Mining Engineers, and now requires only the sanction of the members of the Institute of Metals.

Will Meet With Foundrymen

The meeting next winter will be held in February, in New York, the program to consist principally of technical papers on metallurgical subjects. The program of the fall gathering, however, will consist of papers on practical foundry topics and the meeting will be held simultaneously with the annual convention of the American Foundrymen's association. The headquarters of the Mining Engineers, in the Engineering Societies' building, New York, will be the headquarters of the Institute of Metals division. W. M. Corse, Titanium Alloys Mfg. Co., Niagara Falls, N. Y., is president of the American Institute of Metals, and F. L. Wolf, Ohio Brass Co.,

Properties of Manganese Bronze Test Coupons

Results Show That the Physical Characteristics of Coupons and Castings Are More Nearly Alike Than Other Nonferrous Alloys

IN A recent issue of the *Journal of the American Institute of Metals* an interesting discussion of a paper by W. M. Corse and G. F. Comstock on "Some Comparative Tests on Test Bars and Actual Castings", presented at the last annual meeting of the institute, is presented by F. C. Langenberg, metallurgist,

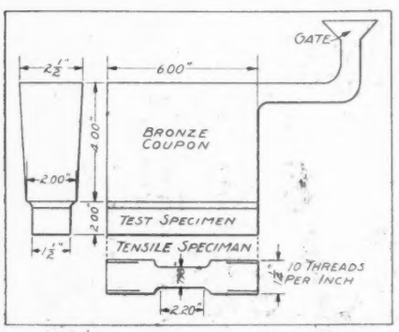


FIG. 1—SKETCH OF COUPON USED IN MANGANESE BRONZE WORK AT WATERTOWN ARSENAL

and J. A. Powell, of the testing laboratory, Waterfown arsenal, Watertown, Mass. Their results were obtained from

Table I

Properties of Manganese Bronze Test Coupons

Specimen taken from		Tensile strength lbs. per sq. in.	Elongation in 2 in. per cent	Reduction of area, per cent
Coupon	A....	65,600	12.0	4.4
Casting	A....	62,400	21.0	23.0
Coupon	B....	78,800	15.2	16.3
Casting	B....	69,200	13.5	16.3
Coupon	C....	71,200	13.0	16.3
Casting	C....	62,600	9.5	14.0

manganese bronze made under the specifications of tensile strength of 60,000 pounds per square inch and an elongation of 20 per cent. Fig. 1 is a sketch showing the coupon used in their bronze work. This kind of test-coupon was used for all the heats on which data were submitted.

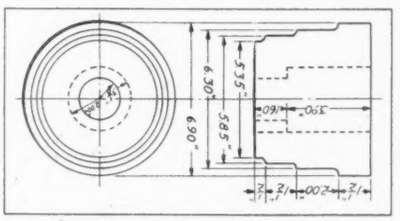


FIG. 2—SIZE AND SHAPE OF THREE CASTINGS FROM DIFFERENT HEATS CUT TO SECURE TEST SPECIMENS

Fig. 2 is a diagram showing the size and shape of three castings made from different heats, which were cut to secure test specimens to compare with the

Table II

Specimen taken from		Tensile strength lbs. per sq. in.	Elongation in 2 in. per cent	Reduction of area, per cent
Coupon	D....	70,000	11.5	11.6
Casting	D....	57,500	8.0	9.5
Coupon	E....	66,800	16.0	16.3
Casting	E....	60,000	29.0	30.7

regular test coupons for the respective heats. The location of the test specimen in the casting is shown on the diagram. The sectional area of the tested portion in each casting or coupon was 0.5 square inch. The results of tests on these three heats are given in Table I.

Fig. 3 is a diagram of two other castings which were from different heats, and were tested similarly in comparison with the regular test coupons for the respective heats. The location of the test specimen in the casting is shown in the diagram, its sectional area in this case was only 0.2 square inch, and its gage length only 1 inch. The coupons, however, were 0.5 square inch in area at the tested portion, and their elongations were determined in 2 inches. The results are given in Table II.

Figs. 4, 5 and 6 are diagrams of castings from each of which only one test was reported to compare with the test of the corresponding coupon. The casting, shown in Fig. 6, was of such a size that the test specimen, whose location

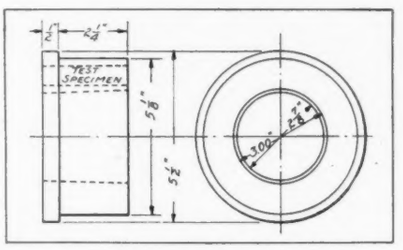


FIG. 3—TWO OTHER CASTINGS FROM DIFFERENT HEATS TESTED SIMILARLY TO FIG. 2

was unfortunately not indicated, was only 0.2 square inch in cross-section at the tested portion instead of 0.5 square inch as the other casting specimens and all the coupons were, and its elongation was measured in 1 inch instead of the

Table III

Specimen taken from	Fig. No.	Tensile strength lbs. per sq. in.	Elongation in 2 in. per cent	Reduction of area, per cent
Coupon F	.	52,000	21.5	20.8
Casting F	4	47,600	15.0	20.8
Coupon G	.	75,600	17.0	18.6
Casting G	5	68,600	15.0	16.3
Coupon H*	.	52,000	13.0	20.8
Casting H	6	62,500	†	30.7

*Blowholes.
†33.0 per cent in 1 in.

usual 2 inches. The results reported for these three heats are given in Table III.

In discussing these results, Dr. Langenberg made the following statement:

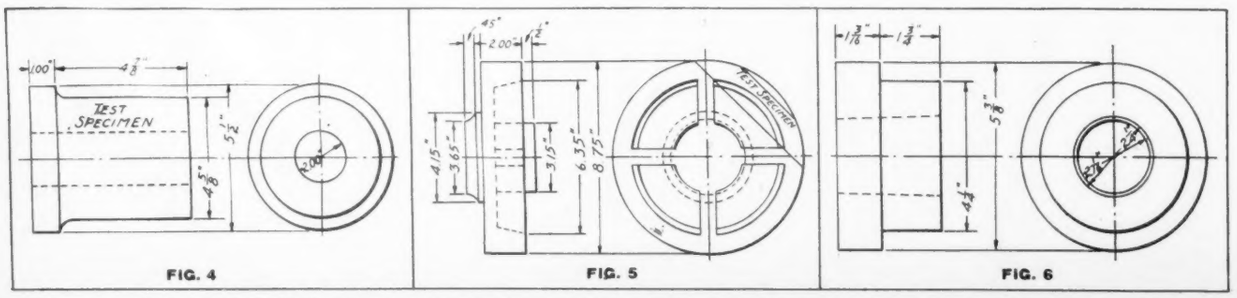


FIG. 4 FIG. 5 FIG. 6

FIGS. 4, 5 AND 6—DIAGRAMS OF CASTINGS FROM EACH OF WHICH ONLY ONE TEST WAS REPORTED TO COMPARE WITH TEST OF CORRESPONDING COUPON

"I do not wish to draw any deductions from these figures. I do know that in a number of cases tests from castings have shown satisfactory qualities whereas the test from the coupon was not satisfactory. I certainly cannot agree with any statement that the coupon is fully 100 per cent better than the casting.

"These sketches from tests are only a few of the many which have been compiled here. It is the practice to observe carefully the appearance of the test specimens taken from the coupon. It very often occurs that the coupon is poured from the last part of the metal remaining in the ladle, and contains a great deal of dross. The test from the casting in such a case as this is justifiable, and very often we have heats which successfully meet the specifications when a test is so taken. It is almost impossible to impress upon a practical melter the importance of taking proper care of the test coupon. He will very often look upon the test coupon as a necessary evil.

Variations in Properties

"The relative properties of the test coupon and the casting cast from the same heat will depend very largely upon how well the casting is fed. If the tests from the castings fall very much below those from the coupon, the trouble can generally be very easily located."

In offering this discussion, Messrs. Corse and Comstock present the following: "We are very glad to be able to submit these data from Dr. Langenberg as a discussion to our paper since it covers an alloy, manganese bronze, on which we did not have any available results of this character. His figures show that with manganese bronze the properties of coupons and castings are more nearly alike than is the case with most other nonferrous alloys, which is what we would expect from our general experience with it in our foundry."

PROBLEMS OF THE BRASS FOUNDER

What To Do and How To Do It

Melting Aluminum in an Oil-fired Furnace

What is the best method of melting aluminum in an oil-fired furnace? In making bronze bushings, 5 inches in diameter, 9 inches long and ½-inch thick, we experience heavy losses from porosity. The castings are cored in green sand. Since the sand is very fine we thought possibly that this might be the cause, but the difficulty persists in spite of ramming soft.

The best flux for aluminum is zinc chloride and a small piece of fused chloride, the size of a nut should be added to 35 pounds of molten aluminum. In melting the metal it never should be permitted to get above a dull red heat. The sand also may be causing some of your trouble and if it is too fine add one-third silica sand and wet with clay wash mixed to the consistency of cream. Run a 1-inch sprue cutter to the bottom of the core leaving a hole that will afford free vent for the gases. Add 0.25 per cent of phosphor-copper to the bronze just before removing it from the furnace. A small amount of salt also should be added to the coal dust used as a cover on the metal.

Mixture for Aluminum Bronze

Will you kindly favor us with mixture for aluminum bronze?

The following alloy makes an excellent aluminum bronze:

Copper, 87.50 per cent; aluminum, 7.50 per cent; iron 3 per cent and manganese, 2 per cent.

When satisfactorily made this alloy should possess the following physical properties: Tensile strength, 74,200 pounds per square inch; elongation in two inches, 39.5 per cent and reduction of area, 31.25 per cent.

The iron is added in the form of loosely rolled tin plate and the manganese in the form of ferromanganese. The amount of iron in the ferromanganese should be deducted from the total amount of iron in the alloy. The copper is melted under charcoal to which the iron and ferromanganese are added; when the bath is molten the aluminum is introduced into the mixture, a small amount at a time. When the final addition of aluminum has been made the iron and manganese will be entirely dissolved. The metal should be cast into ingots and remelted for casting purposes.

Mixtures for Steam Goods

What do you consider a good alloy for brass steam valves taking into account the use of gates as a part of the charge and made from the same mixture? Also kindly let us have a mixture for steam goods other than valve bodies.

The following mixture is used extensively for valve bodies: Copper, 88.5 per cent; tin, 5.5 per cent; zinc, 3.5 per cent and lead, 2.5 per cent.

One concern uses copper, 76 per cent; zinc, 10 per cent; lead, 10 per cent, and tin, 4 per cent.

The gates can be used in any proportion to new metal as desired; for example, 3 per cent gates, scrap, etc., and 67 per cent new metal, or 50 per cent gates and 50 per cent new metal.

A good mixture for ordinary steam goods follows: Copper, 85 per cent; tin, 5 per cent; lead, 5 per cent and zinc, 5 per cent.

Solders for Brass and Aluminum

What are the formulas for solders for brass and aluminum?

Soft solders for brass consist of tin and lead in the proportions of two parts of tin and one of lead. Another well known solder consists of one-half tin and one-half lead and still another contains two parts lead and one part tin. Most commercial solders also contain antimony which frequently is added to improve the appearance of the solder. For soldering purposes, however, the absence of antimony is desirable. The solder consisting of two parts tin and one part lead is highly recommended and is made by melting the metals together. Ordinary hard brazing solder consists of 50 per cent copper and 50 per cent zinc. The copper is melted first, followed by the zinc and the alloy is granulated by pouring it from a height into water.

The following alloys are used for soldering aluminum:

Tin, 92 per cent and zinc, 8 per cent.

Tin, 29 parts; zinc, 11 parts; 5 per cent phosphor tin, one part, and aluminum one part.

Tin, 69 pounds; zinc, 29 pounds, and aluminum, 6 pounds.

Melting Yellow Brass

Our specialty has been ornamental bronze work, but we have also decided to make yellow brass castings. What are the best sands and facings to employ and we would like to know how to melt yellow brass in the reverberatory or noncrucible furnace.

The subject of molding and casting yellow brass has never been discussed

exclusively in any work devoted solely to this alloy. We suggest that you engage the services of a good brass molder experienced in making yellow brass castings. This alloy is more difficult to handle than bronze or red brass and the molding methods must be modified accordingly. The alloy will not lie in molds made from sand that has been tempered too much, nor in molds that are rammed too firmly. It is advisable to vent over the patterns with a fine knitting needle to provide an outlet for the gases. The pouring of yellow brass is an important consideration since the metal must be forced into the molds with a view of keeping the heads full to exclude the zinc oxide which otherwise would cause the castings to be pitted over the entire surface.

Oxidation of Copper

In making brass from new metals, a thick slag formed on top of the molten alloy and when analyzed was found to contain more than 50 per cent copper. How can we recover this metal? The alloy mixture consists of copper wire, 94 pounds; tin, 3 pounds, and lead, 3 pounds. Is it necessary to use a flux when melting?

The difficulty that you have experienced was caused by the oxidation of the copper, either before it was melted or while it was being melted. If oxidized before melting, the wire might have been oxidized in burning off the insulation, and if oxidized while melting it was due to your neglect to place charcoal on top of the metal. The copper can be recovered by melting it in a hot fire with granulated charcoal and salt. The resultant metal may be utilized by small additions to each heat.

An alloy of the proportion given is too rich in copper and is liable to be porous as no deoxidizing agent is present. We suggest that you substitute the following mixture: Copper, 87 per cent; tin, 3 per cent; lead, 3 per cent, and zinc, 7 per cent. Melt the copper with charcoal and a small amount of salt by packing the crucible full of the wire. Cover this with charcoal and a small handful of salt. Melt this charge and then add gradually and as rapidly as it will dissolve, the balance of the copper wire, maintaining a thick cover of charcoal over the metal. When all of the copper has been melted add the zinc which previously has been warmed and follow with the tin and lead, stirring thoroughly in the meantime. A flux composed of plaster of paris with 10 per cent salt can be employed satisfactorily using about 1 per cent of the metal charged. This flux should be added with the charcoal to the copper before melting.

Melting Nickel for Casting Purposes

We contemplate the manufacture of nickel castings and would like to know how this metal may be melted to advantage and the type of furnace that will be necessary to install.

The melting point of nickel is approximately 1450 degrees Cent. and that of copper, 1083 degrees Cent. Therefore, if any difficulty is experienced in melting the copper, you would be unable to obtain a sufficiently high temperature in your furnace to melt nickel. If you are going to produce nickel castings regularly, it is advisable to install an oil-fired crucible furnace, or if gas can be obtained, this fuel may be used. A natural draft furnace also may be provided with forced draft and if fired with anthracite coal, no difficulty should be experienced in melting nickel. For a covering, use a flux of three parts lime and one part fluorspar. Allow the metal to melt by gravity as quickly as possible in preference to poking it down into the crucible with a bar. The nickel can be deoxidized with magnesium, using 1½ ounces for 100 pounds, or with manganese in the form of 30 per cent manganese-copper, using it in the proportion of 0.25 per cent.

Bronze Castings to be Subjected to Hydraulic Pressure

We are making bronze castings that are subjected to hydraulic pressure, but we are experiencing some trouble in getting them to hold water. We are using old metal in our mixture which previously was employed in the same kind of castings.

The addition of 0.25 per cent of phosphor copper to your metal might insure sound castings. The use of about 1 per cent of plaster of paris mixed with a small amount of common salt might remedy the difficulty, if the phosphorus cannot be obtained. If the scrap contains zinc, add 1 to 2 per cent additional to compensate for melting losses and also about 1 per cent of lead.

Excessive Shrinkage of Aluminum

Aluminum vacuum sweeper castings which we are making, developed shrinkage cracks on their upper surfaces and we would like to know the cause of this trouble. We have tried chilling this part, using dry molding sand; we have poured hot and poured cold; we have changed the mixture, but regardless of all these expedients about 50 per cent of our castings are defective.

As this trouble is caused by shrinkage it cannot be remedied by any of the experiments which you have made. Where the loss is so high, it would pay you to reduce your output of castings and to exercise greater care in molding. On the sample casting submitted the gate is very heavy in proportion to the section of the casting and the sprue extends only a trifle above the top of the casting which is run from the bottom. We suggest that the gate be located on top of the high part of the core, connected to the middle section of the casting by a broad, thin gate, which should sharply increase in thickness in the cope to its point of juncture with the sprue.

Adding Ferromanganese to Brass Mixtures

How should ferromanganese be added to a brass mixture for casting large propellers? At present we are melting the copper in a cupola, adding the zinc in the ladle and the manganese is introduced into the mixture in the ladle, either before or after the first tap of copper.

It is doubtful if ferromanganese will melt when the copper is tapped onto it since its melting point is considerably higher than that of copper and it does not wash down to any extent into solution with copper. The best method of adding ferromanganese would be to crush it and melt it in the crucible furnace with copper to produce manganese-copper which would dissolve in the molten copper tapped from the cupola. If there is any question about the manganese-copper dissolving, it should be alloyed with zinc in the proportion of 50 per cent manganese-copper and 50 per cent zinc.

Black Bell Metal Alloy

We would like to have some information regarding the best method of casting large name plates. Also advise us what is known as a black metal alloy.

To cast large bronze name plates successfully, it is advisable to obtain the services of men skilled in this particular line of work, otherwise your men will have to become proficient by experience, and in learning the tricks of the trade the casting losses will be heavy. Therefore, it is more economical to offer satisfactory inducements to men experienced in this line of work than to attempt to educate someone of your own force. It is exceedingly difficult to give advice on this subject since the success of work depends so largely upon the individual skill of the molders.

There are no black alloys of nonferrous metals other than an alloy of 50 per cent copper and 50 per cent silicon, which is too brittle for commercial use. A better alloy consists of copper, 80 per cent and tin, 20 per cent

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

FORMULAS FOR THE BRASS FOUNDRYMAN

CHEAP BRASS MIXTURES

Imitation Manganese Bronze

	Pounds
Copper	59.00
Zinc	40.00
Aluminum	5 ounces
Tin	5 ounces
Tin plate clippings	6 ounces

First melt the copper under charcoal; when hot, add the tin plate loosely rolled; stir, add the aluminum, stirring again, and introduce the zinc in small pieces; when thoroughly incorporated, add the tin. If an easy cutting metal is desired, add several pounds of lead to this alloy in place of an equal amount of zinc.

Cheap Yellow Brass

	Pounds
Copper	60.00
Zinc	36.00
Lead	4.00

Cheap Red Brass

	Pounds
Scrap copper wire	40.00
Zinc	7.50
Lead	7.50
Machinery brass scrap	45.00

Melt the scrap brass first and when hot, add the copper as rapidly as it can be dissolved; follow with the zinc and the lead. This makes a good, ordinary red metal.

Cheap Red Brass from All New Metals

	Pounds
Copper	83.00
Lead	8.50
Zinc	6.50
Tin	2.00

FORMULAS FOR THE BRASS FOUNDRYMAN

CHEAP BRASS MIXTURES

A Tough, Bending Alloy

	Pounds
Copper	84.50
Zinc	10.00
Lead	3.00
Tin	2.50

This alloy is suitable for trolley ears, splicers and other castings where a tough alloy that will bend without cracking, is required. Melt the copper and add the zinc, lead and tin in the order named.

A Half Red and Half Yellow Alloy

	Pounds
Copper	55.00
Zinc	10.00
Lead	5.00
Yellow brass scrap	30.00

When the copper nears the melting point, add the yellow brass scrap and run down together; then add the zinc and the lead. This alloy has been used extensively for sprinkling wagon castings. The castings come out of the sand having a rich red color externally, but when cut, are yellow inside.

Seal Metal No. 1

	Pounds
Copper	80.00
Zinc	7.50
Lead	7.50
Tin	5.00

Seal Metal No. 2

	Pounds
Copper	76.50
Zinc	9.50
Lead	9.50
Tin	4.50

The Waste-Heat Boiler for Malleable Furnaces

The Theory of This Unit is Discussed and the Advantages of Its Application in Malleable Cast Iron Foundries is Pointed Out

By Arthur D Pratt

IT has been said that steam generating apparatus in general use today represents nothing essentially new. If this statement is limited to boiler pressure parts, and a distinction made between the improved details of construction and changes in design, it may be broadly accepted as correct. There is one class of boiler which perhaps should not be included with those covered by the foregoing statement, namely, the waste-heat boiler in the state of development which it has reached within the past few years. Such boilers, while they differ from standard direct-fired types rather in arrangement of heating surface than in radical alterations of design, still utilize a theory that as yet has been tried only in the waste-heat field. And for that reason they may be considered something new in the art. The use of boilers for the reclamation of heat in the waste gases from various industrial furnaces is not new. The first water-tube boiler installed for this class of work was in connection with a puddling furnace at Baltimore in 1874 and for a number of years previous to that time cylinder and flue boilers had been used for the purpose. Many boilers have been installed for use with waste gases. Until 1912, however, practically all such installations were in connection with furnaces discharging gases at high temperature, and it was ordinarily considered impracticable to generate steam commercially with waste gases the temperature of which was below 1600 degrees Fahr.

Practically all the installations prior to 1912 consisted of direct-fired types of boilers or such types but slightly modified and so arranged as to allow the waste gases to pass over the heating surface in place of the products of combustion from a coal fire. The modifications from the standard direct-fired types, and the main feature of design of the boilers built especially for waste-heat work, consisted of an increase in gas passage area.

What may be called the modern type of waste-heat boiler was developed as a result of a study of the rates of heat transfer determined from a great number of reliable boiler tests.

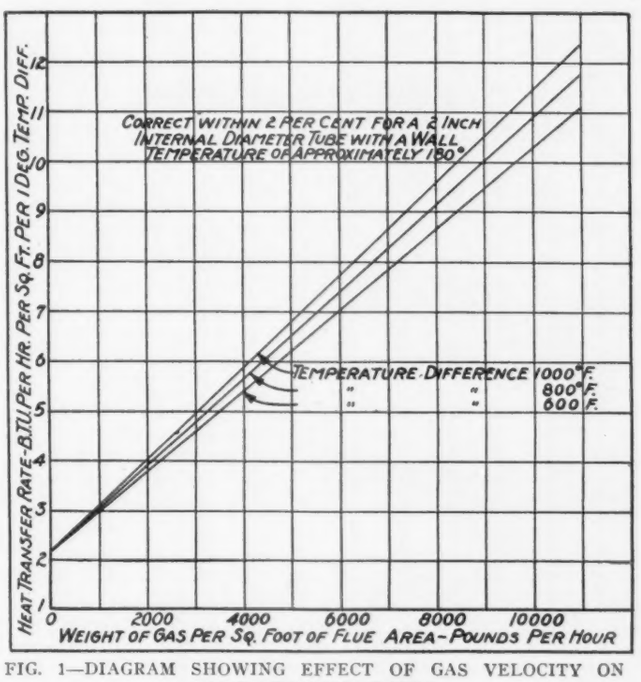

HEAT TRANSFER RATE-B.T.U. PER HR. PER SQ. FT. PER 1 DEG. TEMP. DIFF.
CORRECT WITHIN 2 PER CENT FOR A 2 INCH INTERNAL DIAMETER TUBE WITH A WALL TEMPERATURE OF APPROXIMATELY 150°
TEMPERATURE DIFFERENCE 1000°F.
" " 800°F.
" " 600°F.
0
2000
4000
6000
8000
10000
WEIGHT OF GAS PER SQ. FOOT OF FLUE AREA-POUNDS PER HOUR

FIG. 1—DIAGRAM SHOWING EFFECT OF GAS VELOCITY ON HEAT TRANSFER RATES

The rates so determined indicated such possibilities in heat absorption from low and high temperature waste gases that an extended series of experiments was undertaken to determine definitely the laws governing the rate of transfer of heat from a hot to a cooler medium.

For a given amount of heating surface and a given gas weight, the total heat absorption will be dependent upon the mean temperature difference between the absorbing surface and the cooling medium and upon the rate of heat transfer, ordinarily expressed in British thermal units per hour per square foot of surface per 1 degree difference in temperature. The transfer rate in turn is dependent upon the mean temperature difference and the gas velocity. Because of the wide fluctuation in the density of the gases with the temperatures, and hence in the velocity, it is easier to express such velocity in terms of gas weight per square foot of gas passage area, and it is so expressed in considering the design of the modern boiler using waste heat. The effect of gas velocity on heat transfer is best indicated by the consideration of a hypothetical case. Assume that with a given weight of gas and a given amount of absorbing surface, we have two sets of temperature conditions, under the first of which the mean temperature difference between the absorbing surface and the gas is 900 degrees, while under the second set this mean difference is 600 degrees. Obviously, if the total heat absorption in the two cases is to be the same the transfer rate for the lower temperature difference must be 1.5 times that for the higher difference. The heat-transfer expirements indicated that with moderate gas velocities, the effect of temperature difference on the rate of heat transfer is small as compared with the effect of gas velocity. Neglecting for the moment, then, the fact that the temperature difference in the two assumed cases is not the same, and considering the transfer rate as dependent only on the gas velocity, with the gas weight and amount of surface fixed as outlined, the only way in which the total heat absorption under the second set of temperature conditions could be made equal to that under the first set—that is the only way the transfer rate could be increased 50 per cent—would be through the rearrangement of the given heating surface to give the necessary increase in gas velocity.

Fig. 1, a partial reproduction from the experiments on the rate of heat transfer, indicates clearly the effect

Presented at the Boston convention of the American Foundrymen's association.

of gas velocity on transfer rates. This shows such rates for mean temperature differences of 600, 800 and 1000 degrees, which would cover the range to be found in nonregenerative malleable furnace waste-heat practice. It is true that the experiments were conducted with a gas passage channel of given dimensions and that supplementary experiments proved that a change in the linear dimensions had an effect on the transfer rate. On the other hand, we are for the present endeavoring to show the very great bearing that gas velocity has on transfer rate, and for this purpose Fig. 1 serves admirably.

Theory of Waste-Heat Boiler

If the heating surface for our first set of temperature conditions were so arranged as to give for a mean temperature difference of 900 degrees, with a gas weight of 2000 pounds per hour per square foot of gas passage area, provided Fig. 1 is accepted as approximately correct for a modern waste-heat boiler, this same surface, to give the 50 per cent increase in transfer rate necessary for an equal total absorption with a temperature difference of 600 degrees, would have to be so arrangd to give a gas weight of 6800 pounds per hour per square foot of area. This consideration makes plain the theory upon which the design of the modern waste-heat boiler is based, namely, high gas velocity.

The gas velocity which will give the best commercial return for different classes of waste-heat work will vary with the temperature of the gas, the amount and nature of the dust carried by the gas and, to an extent, upon the draft requirements of the primary furnace. Experience with practically all of the types of furnace from which waste gases are available has pretty definitely determined what such velocity should be for a specific set of conditions. It is hardly within the scope of the present paper, however, to discuss this phase.

It may be generally stated that other things being equal the higher the temperature of the waste gas the higher should be the gas velocity. A partial explanation of this statement is given by a consideration of the heat absorption through radiation in the furnace of a direct-fired boiler as compared with that in a waste-heat unit utilizing high-temperature gas. In direct-fire practice such absorption, in terms of the total heat absorption, is very much greater than is ordinarily appreciated, and for differents sets of furnace conditions the absorption through radiation per unit of exposed surface will vary as the fourth power of the absolute furnace temperature.

Compare, then, a direct-fired boiler equipped with an underfeed stoker and a waste-heat boiler, assuming that the amount of absorbing surface and the amount of radiating surface is the same in the two units. The furnace temperature in the case of the underfeed stoker will probably be in the neighborhood of 2800 degrees. If the temperature of the gases entering the waste-heat boiler is 2000 degrees, this may be taken as the furnace temperature. The total absorption through radiation then will vary as

$$(2800 + 460)^4 : (2000 + 460)^4$$

or the absorption, in the case of the direct-fired boiler, will be somewhat over three times as great as that in the waste-heat unit.

This difference is further aggravated by the fact that in the modern waste-heat boiler the amount of surface exposed to the radiant heat of the furnace is very much less in proportion to the total heating surface than in direct-fired practice. Under such conditions then, for a given gas weight, the proportionate amount of heat that must be absorbed through convection must be very much greater in the waste heat than in the direct-fired boiler if the exit gas temperatures in the two cases are to be brought to a comparable degree. To increase the absorption by convection it is necessary to increase the heat transfer rate and this, as we have seen, is accomplished by an increase in gas velocity.

Early Practice Opposed to Modern Theory

It is of interest to note that the principle of the early waste-heat boiler installation and the theory as described, upon which the modern waste-heat boiler is based, are diametrically opposite.

Previous to 1913 the sole factor that appears to have been considered in waste-heat installations was the noninterference in the operation of the primary furnace. Almost universally this meant noninterference with the draft at the furnace outlet and for such a condition it was necessary to reduce the draft resistance through the boiler to a minimum. This necessitated large gas passage areas and consequently low gas velocities. The resulting exit gas temperatures were high, but were considered rather advantageous in that they enabled a given height of stack to produce a greater draft than could be expected under normal direct-fire conditions.

With a modern design of waste-heat boiler, on the other hand, high gas velocities are necessary to give the desired heat transfer rates; gas passage areas, therefore, had to be appreciably reduced below the standards for direct-fired practice. This reduction in gas passage area gave a greatly increased draft resistance through the boiler and, further, the low exit gas temperatures secured through the high heat-transfer rate reduced considerably the draft to be expected from a given height of stack.

Draft Difficulties

These two factors have made it impracticable in almost all classes of waste-heat work to meet the draft requirements of the primary furnace with its attached boiler unit by means of a natural-draft stack. The remedy was naturally found in the use of an induced-draft fan, but it was the necessity for the use of such apparatus that was, at first, the stumbling block in having the advantages of the modern waste-heat boiler recognized. Furnace operators could not rid themselves of the impression that any boiler which required an induced draft fan to overcome the draft resistance through it must of necessity interfere with the proper operation of the furnace.

The first few installations of the modern waste-heat boilers with their fans definitely answered this contention of the furnace operators. These boilers were set in connection with open-hearth steel furnaces and, due to the increase in the available draft and the better regulation of such draft, the fans instead of being a hindrance to the furnace operation proved an actual help. It was found that through the installation of fans the length of time required per heat was materially reduced. Such a reduction in time was equivalent to an increase in furnace capacity, and for eight furnaces of different rated tonnage investigated with a view to determining the effect of the boiler and fan installation on furnace operation, the average increased capacity was 12 per cent. As successive waste-heat installations were made with other types of furnaces, improved furnace operation was almost universally noted, though the improvement was perhaps not so marked as in the case of the open-hearth furnace where the draft requirements are the most exacting that has as yet been encountered in waste-heat work.

The induced-draft fans required a certain amount of power for their drive, such amount, for a given gas weight, being dependent upon the draft suction necessary at the fan inlet. It is the practice today to

drive such fans by turbines and this type of apparatus has been developed to a state where, considering its size, the steam consumption is low. Practically all of the heat in the exhaust steam from such turbines can be readily returned to the boiler in the feed, and the net deduction from the total boiler output, due to fan drive, is practically negligible. In a series of tests where the draft requirements at the fan approach the maximum that has as yet been used, the gross power required for the fan drive was 13.1 per cent of the total boiler output. Of the total heat of the steam used in the turbine, 91.1 per cent was returned to the boiler feed through individual heaters, so that the net deduction for fan drive was but 1.17 per cent of the gross output.

Gas Velocity Dependent on Draft Requirements

The statement was made that for a given type of furnace the gas velocity through the attached boiler which will give the best commercial return is dependent to an extent upon the draft requirements of the furnace. This velocity affects the draft resistance through the boiler and, hence, the amount of power required for the fan drive.

The total draft suction which the fan must show at its inlet is made up of the draft required at the outlet of the primary furnace, that required in overcoming the resistance through connected flues, and that required in overcoming the resistance in the boiler. The heat represented in the power required to produce this total draft suction, expressed in terms of steam consumption of the fan drive, must obviously not be greatly in excess of an amount which can be utilized in heating the feed for the individual boiler which the fan serves. Where the steam consumption of the fan drive is above such an amount, the power required is directly chargeable as a loss in the boiler output of the installation.

The net allowable deduction due to the steam consumption of the fan drive with a given furnace must be determined in each individual case from a proper consideration of the conditions of each installation. In general, the greater the draft required at the outlet of primary furnace the greater is the care necessary in the design of the boiler to give the proper gas velocity.

It is natural that the modern waste-heat boiler, embodying as it did principles that were new in boiler design, was at first developed in connection with waste gases whose temperatures had hitherto been considered far below that necessary for successful commercial steam generation. The first boilers, as stated, were installed in 1913-1914 in connection with regenerative open-hearth steel furnaces where the gas temperatures at a point corresponding to the boiler inlet varied from 950 to 1200 degrees.

Success Was Immediate

The success of the first installations was immediate. It was found that with entering gas temperatures as low as 1150 degrees, a properly designed boiler could develop from 70 to 80 per cent of its normal rated capacity. That the steel industry as a whole fully appreciated the enormous savings accruing through the utilization of steam generated from gases hitherto discharged to the atmosphere as waste, is indicated by the fact that there have been purchased and installed within the past 3½ years for use with existing and new open-hearth furnaces approximately 100,000 rated boiler horsepower. The total output of the furnaces to which these boilers are attached is in excess of 10,000,000 tons per year.

A natural result of the success of the modern waste-heat boiler with low temperature gases was the application of the same principles of design to boilers for use with industrial furnaces yielding high temperature gases.

Such gases had been used for years for steam generation, but the results secured with the types of boilers ordinarily used were far below what our newly acquired knowledge of the laws governing heat transfer, and the experience gained with low-temperature gases would lead us to expect from the new design of waste-heat boiler.

The following classes of industrial furnaces may be taken as typical of those yielding high temperature waste gases:

Copper refining furnaces, in which the exit gas temperatures vary over a complete cycle of operation from 700 to 2100 degrees, and average approximately 1500 degrees.

Heating and reheating furnaces, where the temperatures vary from 1600 to 1900 degrees.

Beehive coke ovens, where the temperatures in the flue at a point corresponding to a boiler inlet average from 1900 to 2300 degrees.

Installations of modern waste-heat boilers have been made with all of these classes of furnaces and in operation are as successful as are the boilers set with open-hearth steel furnaces.

The results of a number of tests of the present-day waste-heat boiler with temperatures of waste gases are given in a paper presented by the writer in 1916 before the American Society of Mechanical Engineers, entitled "The Utilization of Waste Heat for Steam Generating Purposes". These results are typical and speak for themselves. There is one test given in this paper that to the author's mind is particularly effective in substantiating the correctness of the high gas velocity theory as applied to boilers for use where waste gas temperatures approach coal-fired practice. The test in question is of a Babcock & Wilcox boiler containing 10,200 square feet of heating surface set in connection with a battery of beehive coke ovens.

At the time of installation, it was the intention to have this boiler handle the gases from a sufficient number of ovens to enable it to develop some 20 per cent above its rated capacity, and it was expected that the amount of gas necessary to develop this capacity would correspond to approximately 3500 pounds per hour per square foot of gas passage area.

The fan equipment furnished, however, was such as to enable a gas weight greatly in excess of this amount to be drawn through the boiler and during the test in question the weight per square foot of area was approximately 4800 pounds per hour. With this gas weight and an entering temperature of 2158 degrees, the boiler developed 192 per cent of its normal rated capacity and cooled the gases leaving the boiler to 477 degrees. The approximate transfer rate as determined in the test was 6.8 British thermal units. It is of interest to note how closely this figure checks with the rate as determined for a corresponding gas weight from Fig. 1. The mean temperature difference existing during the test was approximately 950 degrees.

In a Malleable Foundry Field

Numerous malleable melting furnaces were included among the various types yielding high temperature waste gases with which waste-heat boilers of the class we have termed "early design" were installed. Unfortunately for the purposes of the present paper, while the modern design of waste-heat boiler is giving satisfactory results with a number of high exit temperature industrial furnaces, no installation of such boiler has as yet been made in the class of work in which malleable foundrymen are most interested. It is not possible, therefore, to give any actual results obtained from a modern waste-heat unit with malleable furnaces, but

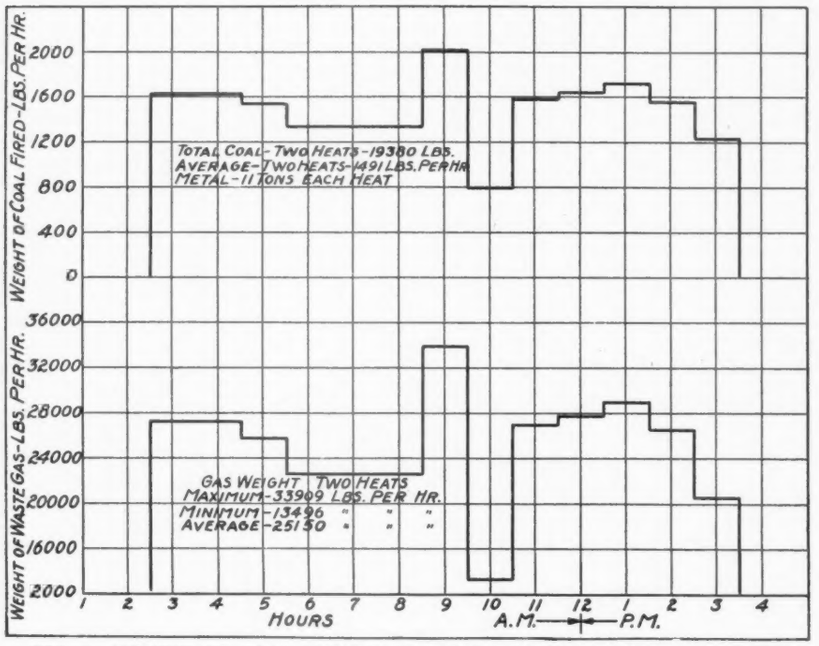


FIG. 2—AMOUNT OF COAL BURNED PER HOUR DURING TWO TEST HEATS AND GAS PRODUCED

there is no apparent reason why such results should not be as wholly satisfactory as with other types of furnaces where the gas temperatures are comparable. Further, enough has been done, both in the theory and the practice of the modern waste-heat boiler, to enable us from a given set of gas conditions to compute within remarkably close limits the boiler capacity and amount of heating surface. A great number of carefully conducted waste-heat tests have been checked against the results theoretically computed for the conditions actually existing in the tests and in no instance has the difference between the computed and actual results been greater than 5 per cent.

On such a basis it is possible to take a given malleable furnace and from a record of the coal burned, the exit gas analyses and exit gas temperature to compute the performance of a given waste-heat boiler of the modern design. Such computed results are, of course, theoretical and possibly somewhat approximate, but our experience through the whole waste-heat field has been such as to lead us to trust computed results almost implicitly.

Through the courtesy of the International Harvester Co., the author obtained data secured by the Arnold Co., engineer, in 1910, in the course of a test on the operation of the first waste-heat boiler attached to a malleable furnace at McCormick works, Chicago. As is the case with numerous forms of industrial furnaces, the operation of no two malleable furnaces, even of the same dimensions, is alike. The data, however, agree in general with that obtained in the investigation of a number of similar furnaces and it appears that the operation of the Harvester furnace may be accepted as typical of the coal-fired nonregenerative malleable furnace.

Eleven Tons Per Heat

The furnace in question, rated at 15 tons, at the time of the tests was being operated at the rate of 11 tons per heat. As in all furnaces investigated, the first or cold heat was some two hours longer than the second or short heat and the coal consumption per ton of metal higher due to the fact that the furnace had been idle for some seven or eight hours previous to the starting of the fires for this heat.

This furnace had attached to it a vertical water-tube boiler rated at 400 horsepower, and the installation may be considered representative of waste-heat practice with high temperature gas previous to the introduction of the modern design of boiler. During the time that the furnace data were secured, a test was run on the boiler and it is thus possible to offer a comparison of the actual performance of an early installation with the expected performance of the waste-heat boiler of today.

The only data missing in the recorded results is the temperature of the gases entering the boiler and this, of course, is necessary for the computation of the expected performance of the proposed boiler. Such temperatures, however, may be determined within close limits of accuracy from the power developed by the existing boiler, the gas temperatures leaving the boiler and the weight and analyses of the gases passing through the boiler, all of these factors varying at different portions of the cycle in operation. The entering gas temperatures have been thus determined and checked within reasonable limits with gas temperature readings obtained in the investigation of a number of similar furnaces.

The comparison of the actual and

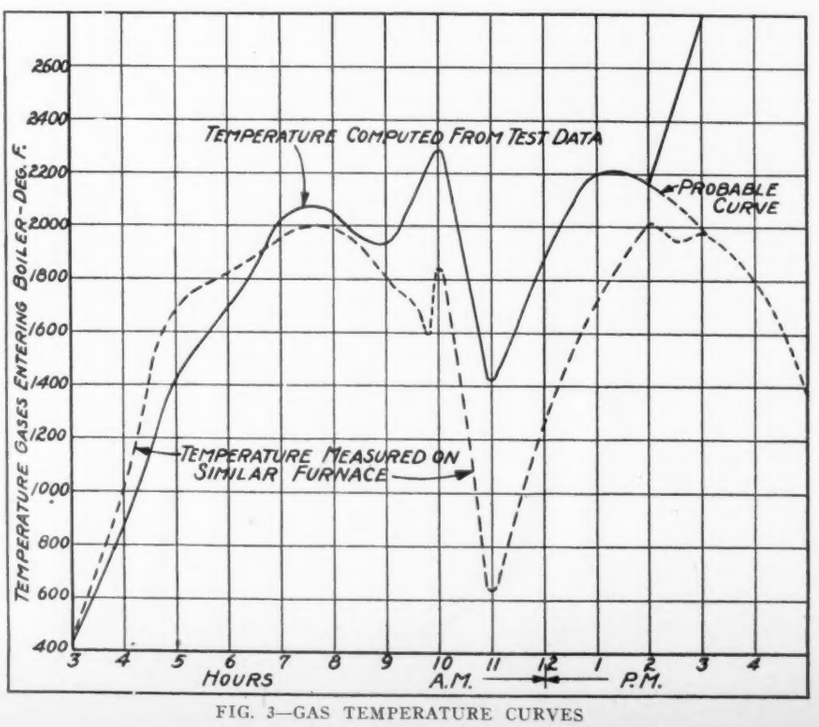


FIG. 3—GAS TEMPERATURE CURVES

expected performance is most clearly indicated by a graphic representation and this is the method followed.

Fig. 2 shows the amount of coal burned per hour during the two heats. From this coal weight, its analysis, and an analysis of the flue gases covering the different portions of the cycle, the weight of gas available for the generation of steam may be computed. These gas weights are also shown in Fig. 2.

Computed Results Verified

The temperature of the gases entering the boiler for the different portions of the cycle computed from the horsepower developed by the existing boiler, Fig. 5, the exit gas temperatures from these boilers, Fig. 4, and the gas weight as given in Fig. 2 are shown in Fig. 3. A temperature curve obtained from a furnace similar to that tested is also shown in Fig. 3 to indicate that the computed temperatures are in line with general malleable-furnace practice.

The only point in the computed temperature curve which appears questionable is the final point. At that time no coal was being fired and the furnace was being tapped. Large quantities of air, which were not measured, were passing through the furnace and being heated in such passage. The boiler capacity developed would thus be the result of heat absorption from a large volume of comparatively low temperature gas, consisting mostly of heated air, rather than a smaller volume of high temperature gas which was actually the products of combustion, and for this reason the weight of gas corresponding to the amount of coal fired for this particular portion of the cycle cannot be relied upon as a means of computing the temperature of the gases entering the boiler at this time. Unquestionably the gas temperature is falling off at the time the heat is being tapped and the direction of the temperature curve is probably as indicated by the broken line in Fig. 3. The probable curve would correspond in general direction to that at the end of the cold heat, theoretically.

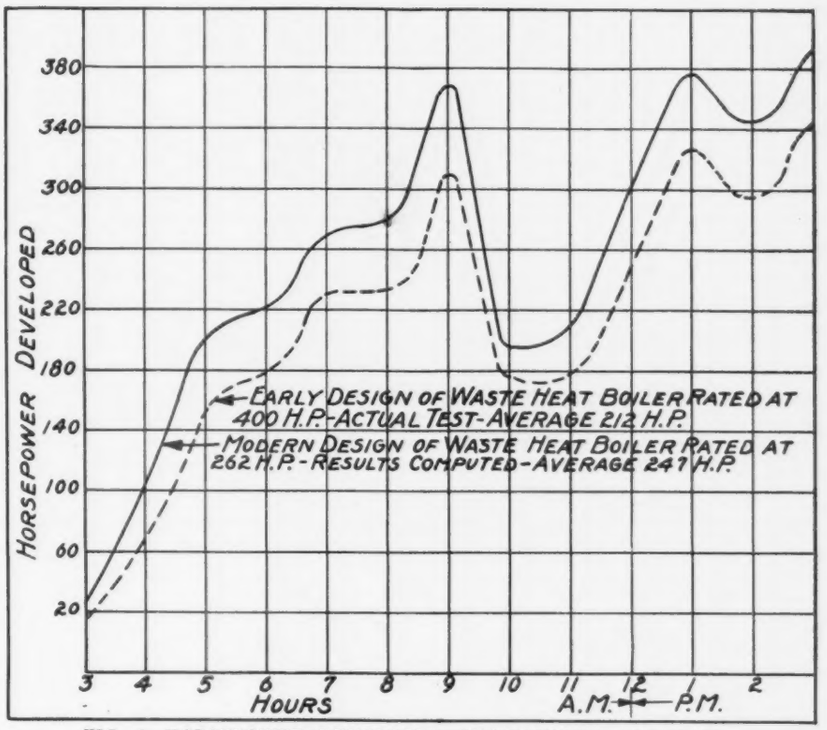


FIG. 5—HORSEPOWER DEVELOPED THROUGHOUT THE CYCLE

The exit gas temperatures from the boiler installed and the capacity it developed for different hours of the cycle are shown in Figs. 4 and 5, respectively.

For the conditions of gas weight and temperatures as determined by this test, the modern high gas-velocity waste-heat boiler which would probably give the best commercial return would contain approximately 2620 square feet of heating surface and would be normally rated at 262 horsepower. Since superheaters are installed in the majority of waste-heat boilers, it is assumed that superheated steam could be used in the present instance and that the boiler is equipped with a superheater containing approximately 10 per cent of the boiler surface.

The exit gas temperature we would expect from this proposed boiler, utilizing the gas weights as given in Fig. 2 at temperatures, as shown in Fig. 3, are given in Fig. 4. The horsepower to be expected from this boiler and its superheater throughout the cycle is shown in Fig. 5. The expected output, as shown, is, of course, the result of a theoretical computation, but, as stated, our experience has given us almost absolute confidence in results so calculated.

Advantages Are Obvious

If, then, we accept these results as even approximately correct, the advantages of the modern waste-heat boiler are obvious. We see such a design of boiler, containing, with its superheater, but 72 per cent of the surface of the boiler which is actually in operation and which may be taken as typical of waste-heat practice, developing from 14 to 55 per cent more horsepower at different portions of the cycle, and averaging for the two heats 16.5 per cent greater output. In terms of the normal rated capacities of the two boilers, the average capacity developed for the two heats for the boiler installed is 53 per cent, while for the modern design of boiler this percentage of normal rated capacity would be 94 per cent.

It is true that the draft loss through the modern waste-heat boiler would be considerably in excess of that through the boiler installed and that the total draft suction required for the former would necessitate the installation of an induced draft fan. Malleable furnaces, however, are all apparently operated with a slight pressure at the exit throat, and the power required to drive the fan is only that necessary to overcome the frictional

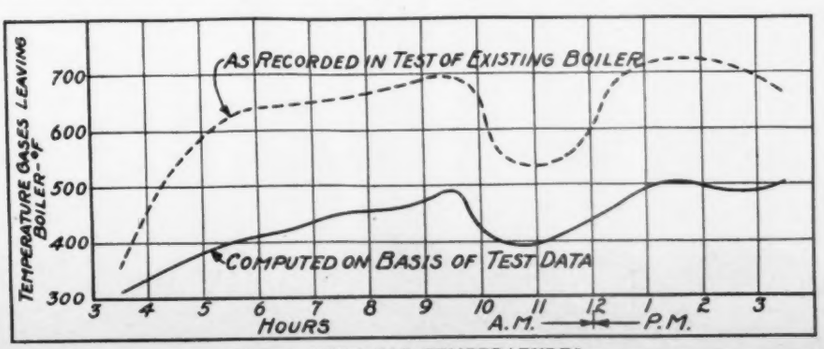


FIG. 4—EXIT GAS TEMPERATURES

resistance of the gases in their passage through the boiler. This amount of power, for the particular class of waste-heat work in question, is practically negligible.

The maximum draft suction at the outlet of the boiler installed was 0.79-inch during the test. The suction required at the outlet of the proposed boiler would naturally be greatest when the greatest weight of gas was being handled and the greatest capacity was being developed. The suction necessary under such conditions would not be in excess of 2 inches, though, to allow a margin of safety, the fan installed would probably be designed to show 2.5 inches when handling the maximum gas weight. Even assuming the latter suction necessary and a fan efficiency of 50 per cent, which is certainly conservative, the indicated horsepower of the fan would be only 9.1. The smaller sizes of steam turbines have been developed to a stage where the steam consumption is as low as 33-36 pounds per indicated horsepower hour, but again, to be conservative, assume this rate to be 45 pounds. At such a rate, the gross power required to drive the fan in terms of boiler output would be 17.5 boiler horsepower, or approximately 5 per cent of the total. Since at least 85 per cent of this power may be regained through the use of the turbine exhaust in a feed water heater, the net loss due to fan drive will be 2.6 boiler horsepower, or less than 0.75 per cent of the total boiler output.

Power Generated Will Vary

Fig. 5 indicates that the amount of power generated by an individual boiler will vary over a wide range at different portions of the complete cycle. Where a number of furnaces are equipped with waste-heat boilers, all of which are discharging into a common steam main, the fluctuation would unquestionably be less due to the unavoidable variation in the operation of the different furnaces. Even under such conditions, however, the variation in total steam supplied might be objectionable and it probably would be advisable to equip all boilers in this class of work with auxiliary furnaces. Such furnaces might be arranged for coal-firing, for oil or for natural gas. Where either of the latter two fuels are available, the results to be secured through their use would, from an operating standpoint, probably be more satisfactory. This is due to the fact that during the hours between the last tap and the hours of firing for the next day's heat, when the auxiliary furnace would be of most service, there is ordinarily a scarcity of labor about the plant. With either oil or natural gas, the water tender could readily attend the operation of several auxiliary furnaces, whereas if the furnaces were hand-fired it would probably necessitate the employment of additional men to handle coal and ashes. Such auxiliary furnaces would not only enable the boilers to carry a reasonably constant load, but also would allow steam to be generated during periods in which the furnaces are not in operation.

Since no installations of the modern waste-heat boiler have been made with malleable furnaces, it is only possible to indicate how such a furnace might be so equipped. Fig. 6, however, will serve to illustrate such an installation. While this illustration shows a coal-fired auxiliary furnace, a similar arrangement could be worked out for either oil or natural gas as the auxiliary fuel.

In the foregoing discussion, only the reverberatory type of malleable furnace has been considered. A number of regenerative furnaces were observed in the investigation of the subject and it would appear that the operation of such furnaces, insofar as fuel and temperature conditions are concerned, is analogous to that of an open-hearth steel furnace. The low gas weights available from the individual regenerative malleable furnaces, taken together with the low temperatures that accompany the use of the regenerative principle, would probably make the installation of waste-heat boilers on individual furnaces impracticable. It is possible that such an installation might be made with a number of furnaces operating on the same cycle, though this feature has not as yet been considered.

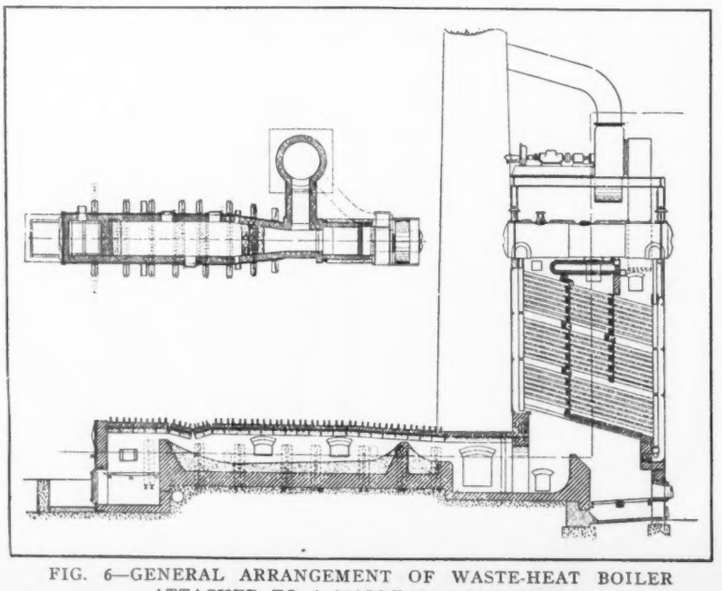


FIG. 6—GENERAL ARRANGEMENT OF WASTE-HEAT BOILER ATTACHED TO A MALLEABLE FURNACE

Removal of Phosphorus and Sulphur in the Cupola

By W. J. Keep

Question:—The question has been propounded as to whether phosphorus can be eliminated in the cupola by any means, such as slagging-off, or the use of a basic lining, or in short, by any means other than changing the mixture to be charged. I have never heard of any method being employed to accomplish this and would like to know if you think any experiments along this line would be practical.

Answer: — Experiments have been made by chemists to decrease both of these elements, but with meager results. The basic lining of an open-hearth melting furnace will decrease phosphorus, but the molten metal in a cupola does not lie against any part of the lining long enough to have its composition produce any effect. The metal, before and after melting, however, does come in close contact with the fuel, which gives up its sulphur and in rare cases, its phosphorus to the iron. The addition to the charge of ferro-manganese and lime will decrease the sulphur to some extent, but it is estimated that the melted iron will pick up about 0.03 per cent of sulphur, but will not take any phosphorus from the fuel and will not give any to the slag. Occasionally statements are made that someone has discovered a way to decrease sulphur, but up to the present time no progress seems to have been made. Low-phosphorus and low-sulphur pig iron can be purchased and steel scrap can be added to still further reduce these elements. The scrap, or remelt, can be melted separately and poured into castings of no importances.

Growth of Gray Cast Iron by Repeated Heating

The Author Has Carefully Investigated This Phenomenon With Particular Reference to Cylinders and Pistons for Internal Combustion Engines

By J E Hurst

ONE of the chief drawbacks to cast iron from the point of view of high-class engineering construction is its behavior on reheating. The deterioration of the mechanical properties of this material after prolonged exposure to high temperatures is perhaps the greatest drawback to its use in engine construction.

The phenomenon of growth, though it has been previously mentioned by other observers, was first brought seriously to the front by Alex. E. Outerbridge.

The phenomenon was thoroughly investigated later by Professors Carpenter and Rugan. As a result of this investigation the factors at work in the production of this permanent swelling or growth in gray cast iron were brought to light. These investigators showed that by the repeated heating and cooling of gray cast iron, growth can be brought about to an enormous extent, an increase in volume of something like 60 per cent being obtained in some of their experiments. This enormous increase in volume of the cast iron was shown to be due principally to the penetration of oxidizing gases of the muffle into the interior of the cast iron and consequently bringing about oxidation of the constituents internally. According to Dr. Stead the oxidation of the constituents takes place in the following order: Iron, silicon, phosphorus and graphite.

The relative order in which the constituents are oxidized does not always appear to be that suggested by Dr. Stead. In this connection the following instance of a gray cast iron chill which had been used on a cylinder barrel core, and which was originally ⅜-inch in thickness had expanded to a thickness of ⅝-inch. The fracture of this chill presented a curious appearance and appeared very much like the fracture of a sample of a blackheart malleable casting, with the exception that the outer ring, which was distinctly outlined and of about ⅛-inch in thickness, was not steely, but of a light gray appearance. The analyses of the outer ring and the core of this chill are given below:

	Outer ring, per cent	Core, per cent
Combined carbon	0.17	0.32
Graphitic carbon	0.90	0.90
Silicon	2.19	2.24
Manganese	0.55	0.58
Sulphur	....	....
Phosphorus	1.48	1.51

Curiously, very little difference is apparent in the analyses with the exception of the combined carbon. The most important point to note, however, is the low graphite content. The original composition of the chill is not known, but it is apparent that there has been a considerable loss, presumably by oxidation, of the carbon contents. It is clear that the relative order in which the constituents are attacked and oxidized will depend on many factors, which will vary considerably in individual cases. The temperature sustained by the cast iron and character of the surrounding oxidizing atmosphere; the structural arrangement of the constituents of the cast iron at high temperatures, are all factors which influence the growth phenomenon, and, which it will readily be appreciated, vary considerably in individual cases. The latter factor, in all probability, will be found of considerable importance, and is unfortunately but little understood. An interesting example of the effect of heat on gray cast iron is the case of a length of ordinary gray cast iron rain-water pipe.

This pipe had been subjected to the action of heat at a temperature from 900 to 950 degrees Cent., for a considerable number of times, and was eventually scrapped owing to distortion. Although scrapped for distortion, there was no expansion apparent to the naked eye beyond the usual superficial layer of scale, the pipe walls still remaining about ⅛-inch in thickness. An examination of the micro-structure of specimens taken from this pipe would appear to confirm that the extent of growth was negligible.

The fracture of this pipe showed an inner ring or core of gray graphitic iron, surrounded on both sides by a ring of a bright, steely fracture. It was clearly evident that the inner gray graphitic core had been protected from the influence of the oxidizing gases by the formation of a *case* of ferrite with the absence of free graphite, and hence was prevented from growing.

It is worthy of note that the production of a decarbonized skin on the surface of cast iron may offer a means whereby growth may be prevented from

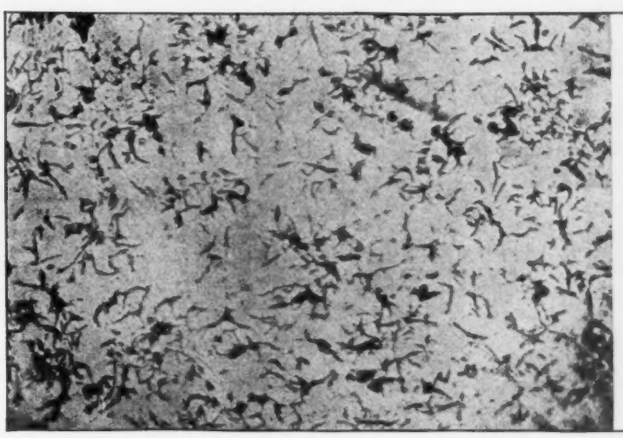


FIG. 1—MICROSTRUCTURE OF GRAY GRAPHITIC CAST IRON BEFORE HEATING

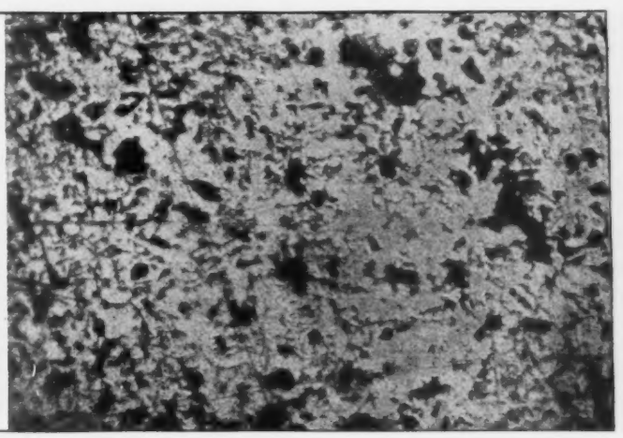


FIG. 2—MICROSTRUCTURE OF GRAY GRAPHITIC CAST IRON AFTER HEAT TREATMENT

From a paper presented before the Staffordshire (Eng.) Iron and Steel institute.

taking place to any large extent. Such a method might be of considerable service in many circumstances, as for instance in the case of dies and complicated chills, where the employment of special white irons may introduce serious difficulties apart from growth. In such cases it is suggested that a high silicon cast iron be employed. This would possess a two-fold advantage, in that the length of time required in the annealing to produce the deoxidized skin would be considerably reduced, and that the initial combined carbon would be so low that the effect of the deposition of temper carbon, due to the dissociation of the pearlite carbide on the expansion would be very small and practically negligible. The author has used this process in several cases.

No Growth in Stove Castings

There are numerous instances of gray cast iron which have been subjected to the influence of heat for considerable periods without growth. There are many cases of castings used in stove grate work, for example, which have withstood the action of repeated heatings and coolings over considerable periods without showing any serious growth. It will readily be appreciated that the particular conditions existing in each individual case are of prime importance in deciding whether or not growth will take place. Further work is still necessary, particularly with a view to deciding the circumstances under which cast iron will *not* grow. In this connection it is important to note that the range of temperature covered by Carpenter and Rugan's growth investigations had for its minimum limit 600 degrees Cent. and for its maximum limit 900 to 950 degrees Cent. In the region below 600 degrees Cent. it is certain that volume changes take place. This phenomenon is regarded by Carpenter and Rugan as different to the growth phenomenon investigated by them. Undoubtedly in the region of temperatures beyond the upper limit mentioned the phenomena met with are likewise of a different character.

We will now discuss internal combustion engine pistons and cylinders. The construction of these parts is probably one of the most important uses in which gray cast iron is employed. The effect of heat on cast iron has always been a considerable difficulty to the internal combustion engine designer in its employment in the construction of these parts, particularly in the diesel engine, and the large gas and oil engines. In a large measure, one of the greatest disadvantages of cast iron in this respect is indirect, and is due to the comparatively low tensile strength and brittleness of this material, necessitating the employment of comparatively thick sections in the piston casting, a fact which, taken together with the low specific thermal conductivity of this material, is a great bar to the rapid dissipation of the heat by conduction to the outer atmosphere. This has led to the introduction of aluminum alloy pistons on the lighter types of internal combustion engines—the motor car and aero engines. In the diesel engine such pistons have not as yet gained general acceptance, a fact which may be ascribed to the much higher temperatures which the piston head has to withstand.

The cracking phenomenon has been shown to occur in diesel engine piston heads unaccompanied by the characteristic feature—oxidation of the growth phenomenon. The reason for the absence of oxidation under these circumstances is still somewhat uncertain since it is undoubted that the conditions in the diesel engine are decidedly oxidizing. In all probability this is to be attributed to a number of causes, the main one of which appears to the author to be that the temperature attained is probably considerably higher for a superficial layer at least than that at which growth has been shown to take place. This is of considerable importance, for at a temperature of between 950 to 1000 degrees Cent. a considerable portion of the free carbon is gradually redissolved in the iron, a fact which it will be obvious considerably retards the entry of the oxidizing gases. In addition, it is extremely uncertain as to what action the gases would have upon the constituents of cast iron at these high temperatures. Probably, in actual practice, the thin layers of carbonaceous matter frequently found deposited on the heads of such pistons, and also the fact that a considerable quantity of oil may collect and remain on the head of the piston, all tend to minimize the chances of the entry of oxidizing gases, and hence prevent actual growth due to this cause.

Knowledge of Phenomenon Incomplete

Our knowledge of the exact changes taking place on the reheating of cast iron is incomplete, but such as it is, it throws considerable light on the causes at work in the cracking of diesel engine piston heads. The heating of commercial gray cast iron to temperatures below 950 to 1000 degrees Cent. invariably results in the dissociation of any pearlite carbide with the production of free carbon in the form of temper carbon. In many cases this dissociation is extremely rapid, and practically the whole of the pearlite carbide can be decomposed in this manner even on quenching from the various temperatures in this range. An examination of specimens which have been subjected to prolonged exposure to heat indicates that a considerable crystalline re-arrangement takes place.

The precipitation of temper carbon, it is known, is accompanied by a slight volume change, and it will readily be seen that this fact, together with the structural re-arrangement which takes place on heating, will tend, under the extremely localized conditions of heating of the internal combustion engine piston head, to set up internal stresses, which, under the conditions prevailing in these engine cylinders—high alternating gas pressures—will rapidly lead to fracture. It is practically certain in the case of the diesel engine, that owing to the high temperatures produced therein a portion of the graphite carbon is reabsorbed.

Preciptation of Graphite

The extent of the reaction of absorbtion will undoubtedly be limited to the zone of the temperature above 950 degrees Cent. On cooling down below this temperature, the reabsorbed graphite is rapidly reprecipitated. It is difficult to determine in what manner this reprecipitated graphite exists. In the first place, it is certain that graphite precipitated under these conditions will be in the temper carbon form. One must assume that the numerous small holes to be seen under the microscope in specimens which have been treated in this manner were originally occupied by temper carbon, and which has been detached during the polishing process. On the other hand, as already pointed out by Dr. Hatfield, a considerable quantity of this temper carbon appears to be drawn into position alongside the already existing graphite plates, thereby causing a swelling of these graphite plates. In this latter case it follows that quite a good many of the holes which were originally occupied by graphite plates, and which are to be seen in the quenched specimens will, under the conditions of slow cooling be unoccupied. It will readily be appreciated how disastrous the effect of this will be on the mechanical strength of the cast iron, under conditions of repeated heating and cooling such as obtain in diesel engine practice, and although the absorption of a considerable portion of the free carbon largely contributes to the prevention of actual growth, the cast iron is rendered thereby considerably weaker, and is less able to withstand the alternating stresses at such high temperatures obtaining in the engine cylinder during working.

In this connection the author would point out that the increase in size of the graphite plates noticed in heat-treated gray cast irons would appear in all cases to be due to the formation of either layers of iron oxide and silica as in actual *grown* cast irons, or to the

drawing into position of temper carbon alongside these graphite plates, and he finds it difficult to obtain evidence of the expansion of the original graphite plates, as such, in gray cast iron on heating. Figs. 1 and 2 show the appearance of gray graphitic cast iron before and after subjection to heat treatment. In Fig. 2 the increased number of large black areas is plainly illustrated.

In many cases the cracking of piston heads is frequently due to mechanical defects such as defective cooling arrangements and badly designed castings. The production of scale or deposit on the interior of diesel engine piston heads from the cooling water, or the production of hard carbonaceous deposits, such as are frequently to be observed in motor car engine pistons, exert a large influence on the freedom of the dissipation of heat. Badly designed castings, in which the sections are of widely varying thickness materially assist in the production of internal strains and the consequent development of cracks.

Phosphorus Influences Growth

The influence of phosphorus has been found to be highly detrimental in diesel engine pistons. It will readily be appreciated that in a large measure this will be due to the liquation of the phosphide eutectic constituent in those portions of the piston head subjected to the direct influence of the heat. The melting point of this constituent lies within the region of 950 to 1000 degrees Cent. That liquation of this constituent does occur in phosphoretic gray cast irons when heated to temperatures within this range has been fully confirmed on experimental specimens. In quenched specimens of phosphoretic gray cast irons heated to these temperatures it is invariably noticed, apart from its liquation, that its characteristic *skeleton* or eutectic structure, which it normally exhibits in slowly-cooled gray cast irons, is replaced by a close, massive constituent which on strongly etching shows a structure which is regarded as that of the ternary-iron-carbon-phosphorus eutectic. This second eutectic is formed by the re-absorption of the black pearlite areas existing normally within the binary eutectic, and possibly in addition some of the graphitic carbon. This point is not yet quite definitely settled, but it is observed that the presence of phosphorus would appear to assist in increasing the rapidity of, and lowering the temperature at which the re-absorption of the graphite in cast iron takes place when heated to these high temperatures.

This being the case, it would appear that the presence of phosphide eutectic, in addition to increasing the magnitude of the internal strains in the heated diesel engine piston head, by reason of the slight volume changes due to its influence on the re-absorption of the graphite, will materially increase the volume of metal in the piston head to be affected in this manner, by reason of its influence on the time and temperature of this re-absorption.

In addition, it is very probably a fact that the presence of phosphide eutectic constituent materially weakens cast iron at high temperatures. It is therefore legitimate to draw the conclusion that phosphorus is decidedly a very dangerous constituent of gray cast iron for internal combustion engine pistons.

The character of the graphite plates also is an important point in cast iron intended for internal combustion engine pistons. Graphite in the form of very fine plates is undoubtedly the most desirable. Their influence is still obscure, but in all probability manifold. Cast iron with finely divided graphite plates undoubtedly possesses higher tensile and shock-resisting properties even at the higher temperatures. The chance of any initial penetration of oxidizing gases into the interior of the cast iron is considerably lessened. The re-absorption of graphite, though in all probability it may take place somewhat more rapidly in the case of finely divided graphite, is localized, and any holes formed as a result of the deposition of this carbon on cooling in juxtaposition with already existing graphite plates, are considerably smaller. It has been frequently noticed that even in pistons containing originally very finely divided graphite plates, these grow considerably in the portions directly subjected to the influence of the heat.

White Iron Recommended

In these days of effective grinding machinery, the author sees no reason why alloy cast iron pistons of the white iron type should not be employed in the diesel engine. The author has experimented with several alloys of this type, and from the point of view of strength, shock and wear-resisting properties, in addition to very effective heat-resisting properties, alloys can be made which possess considerable advantages over gray cast iron, and owing to their lower melting points are at least quite as easy to cast as steel. The internal combustion engine cylinder or cylinder liner, as a general rule, is not called upon to withstand anywhere near so high a temperature as the piston. There are, however, many evidences of slight distortions and volume changes in these parts during actual working, which are in all probability akin to those experienced in cast iron fittings or super-heated steam mains. Broadly speaking, it may be taken that what has already been laid down in connection with pistons will equally apply to liners. Obviously, however, there is not the same necessity for keeping the phosphorus in cylinder liners at quite the same low figures. It is the author's opinion that the presence of phosphorus eutectic improves the wear-resisting qualities of the liner. From the same point of view, the presence of manganese is also advantageous.

Auto Engine for Cupola Blower

During the coal shortage last winter the city of Muskegon, Mich., was without electric power for several days. The large automobile cylinder foundries in this district which depend on central station power for the operation of their cranes, cupola blowers, air compressors, etc., were seriously embarrassed. One of these concerns, the Lakey Foundry & Machine Co., met the emergency by drafting an automobile motor into service. The motor, which was of the 30-horsepower, 6-cylinder type, was obtained from the plant of the Continental Motors Corp., in Muskegon. The Lakey company used it for driving its cupola blower. As an emergency proposition the experiment was entirely satisfactory and the motor has been retained to guard against future fuel shortages.

Another Original Pamphlet

"This, That, Those and These" is the euphoneous title of an exceedingly original and unique house organ which appears at no given intervals, and incidentally only is a reminder of the foundry and platers' supply and equipment business indulged in by its author, Frederic B. Stevens, Detroit. It contains a number of quaint and humorous short stories that are well worth reading, including the following: "Joel Pineapple—Salesman"; "A Newspaper Story", "The Window-sill Club", "The Birth of a Booklet", etc.

Regulus Metal Mixture

By J. B. Orbison

On page 168 of the April issue of THE FOUNDRY inquiry is made regarding Regulus metal. According to the reply the name *Regulus metal* means little in the family of alloys, although the party who placed the order referred to evidently had in mind some particular alloy. Some years ago the writer was called upon to furnish some valves and fittings, the specifications of which called for Regulus metal. They were for use on acid tanks and connections. The alloy was made as follows: Lead, 87 per cent; antimony, 11 per cent; copper, 1 per cent, and tin, 1 per cent.

Fig. 1—Floor of Tractor Axle Housing Molds at 8 a. m. Pouring is Continuous

Molding Machines Facilitate the

WHATEVER curtailment has been effected in the production of castings for automobiles due to the government limitation of pleasure car output this year, this has more than been offset by the requirements of gray iron castings used in the construction of tractors. These power-operated implements now are being produced on a quantity basis almost on a par with that of motor car manufacture, and it is not unusual for foundries to receive orders for from 10,000 to 50,000 duplicate castings for use in one type of tractor alone.

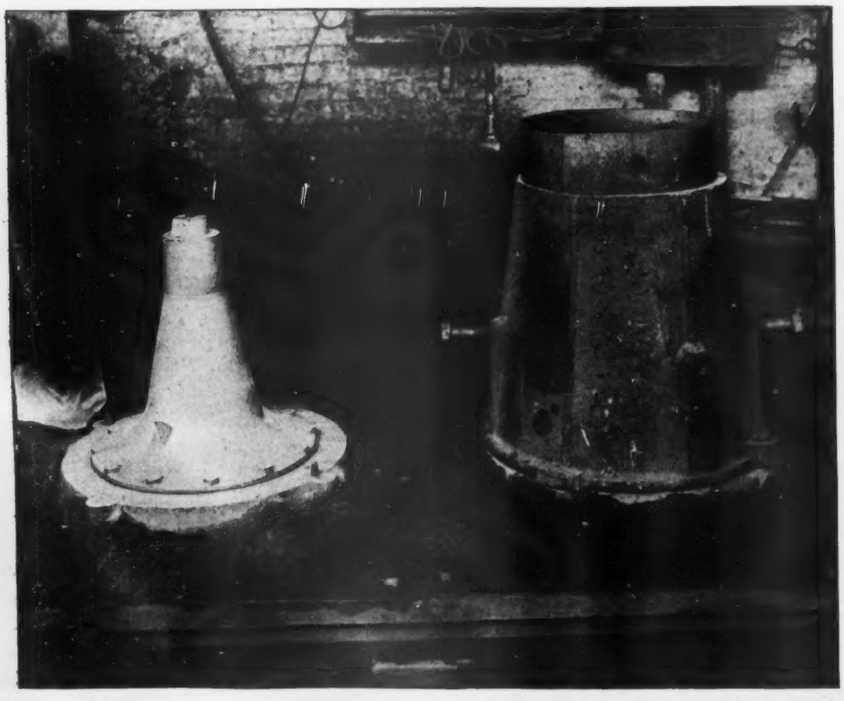


FIG. 2—TRACTOR AXLE HOUSINGS MOUNTED ON COMBINATION JAR-RAMMING, STRIPPING PLATE MACHINE. PATTERN IS SHOWN AT THE LEFT AND AT THE RIGHT A FLASK IS IN POSITION READY TO RECEIVE THE SAND

The Ferro Machine & Foundry Co., Cleveland, is producing a large tonnage of castings for tractors and at a recent meeting of the Detroit Foundrymen's association, John T. Stoney, superintendent of the Ferro foundry, discussed the methods pursued in his plant for the molding and casting of axle and transmission housings for tractors.

Two Drags Rammed in One Operation

In Fig. 2 is shown a jar-ramming machine installed by the Cleveland Osborn Mfg. Co., Cleveland. It is of the stripping plate type and molds the drags of two tractor axle housings in one operation. At the left is shown the pattern for the axle housing and at the right, a special cast iron flask, designed for these molds, has been set over the pattern with a sand frame on top in position ready for the jar-ramming operation. The flasks are filled with sand shoveled into them by hand. In Fig. 2 the stripping plate is in its normal position for jar-ramming the molds.

Fig. 3 shows two tractor axle housing molds lifted off the machine by a bail supported by a crane. This bail, as indicated, handles both drags and the trunnions are so balanced that when the molds are lifted they turn over in position for placing them on the floor. In this view the patterns have been stripped out of the molds by the upward movement of the jar-ramming table. No plates are

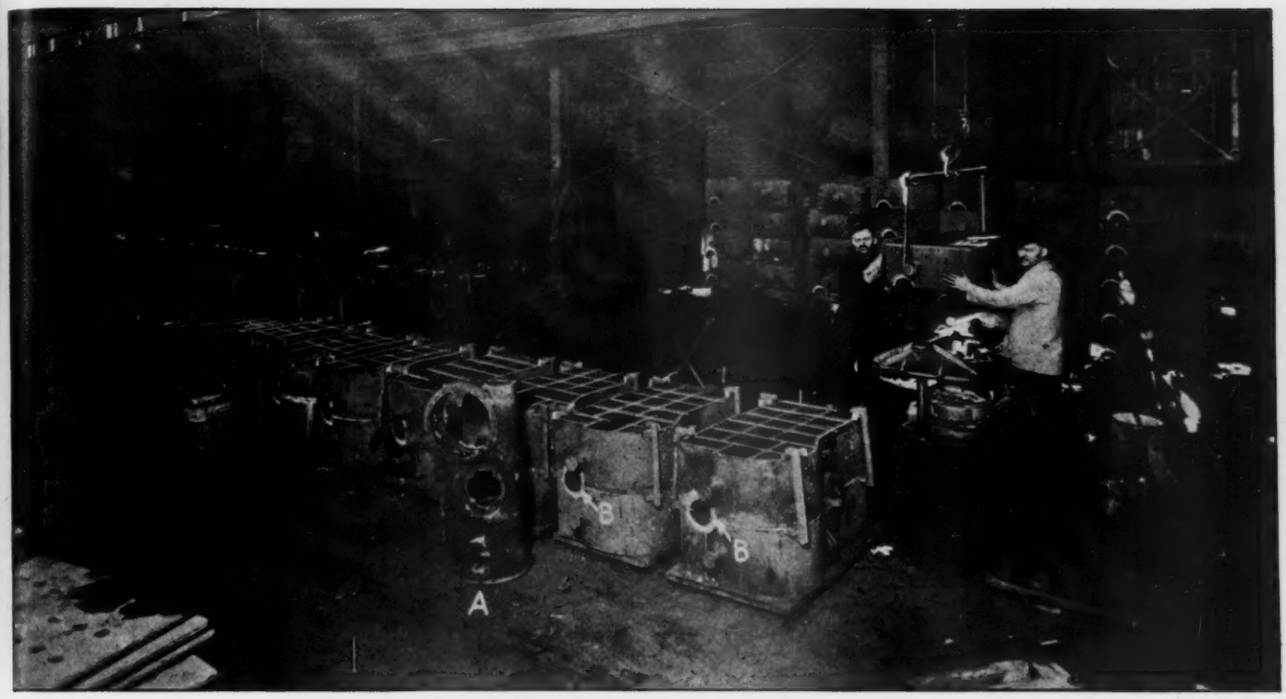


Fig. 3—A Floor of Tractor Transmission Housing Molds at 9 a. m. Each Mold Weighs Over 1000 Pounds and the Castings, 200 Pounds Each

Production of Castings for Tractors

placed underneath these flasks, which are bedded in sand on the foundry floor, as illustrated in Fig. 1. The center core is shown at *A*, Fig. 3 the casting at *B* and *C* is the cope which constitutes little more than the cover of the mold.

The copes are molded on two jar-ramming, squeezer type, Osborn stripping plate machines. Two of these machines are required to finish a sufficient number of copes to cover the output of drags made on the combination stripping plate, jar-ramming machine.

Making the Center Core

The center core is made on an Osborn roll-over machine, but in adapting it to this work, the roll-over attachment was removed and the core box, split in halves, was hinged to the side uprights, as indicated in Fig. 5. The halves of the core box have been hinged in such a way that they swing in opposite directions meeting accurately at the center without further adjustment. This arrangement eliminates the necessity of rolling-over this core box by hand. It is so arranged that when the box is closed it is clamped and is in position for ramming. The output of this core by the use of this device has been greatly increased and this method may be adapted to other cores of a similar type. The molding machine equipped to do this work temporarily was not fitted with a pattern and, therefore, this piece of equipment was restored to use by making a few minor changes that do not impair the utility of the machine for subsequent molding operations.

The axle housings, after cleaning, weigh 65 pounds; they are 24 inches high. The flasks weigh 185 pounds and the entire equipment, including drag and cope molding machines, is operated by nine men who produce 500 molds per day. A floor of axle housing molds at 9 a. m. is illustrated in Fig. 1. Pouring is continuous and as rapidly as the castings are dumped the space thus cleared is utilized again for other molds. The method which is employed for molding these tractor

FIG. 4—DRAG HALVES OF TWO TRACTOR AXLE HOUSING MOLDS AFTER RAMMING AND STRIPPING

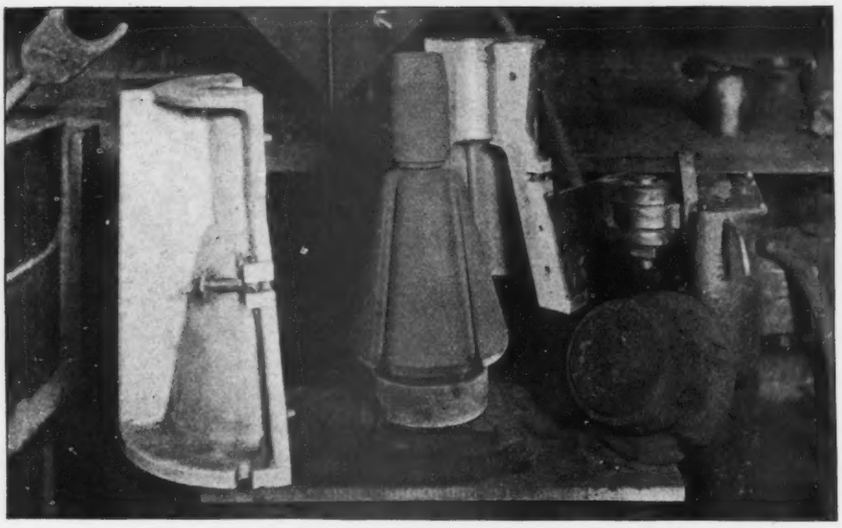


FIG. 5—MAKING THE CENTER CORE

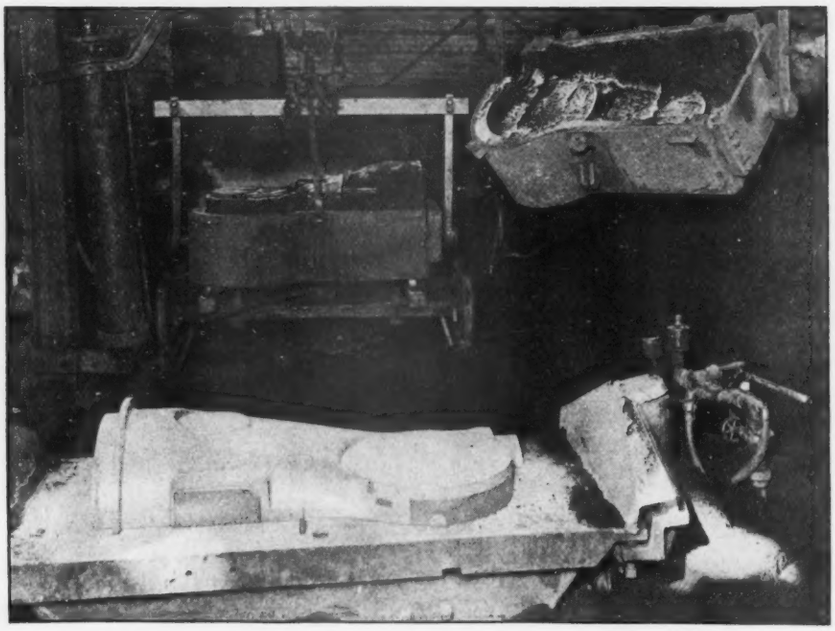


FIG. 6—MACHINE EQUIPMENT FOR MOLDING TRANSMISSION HOUSINGS

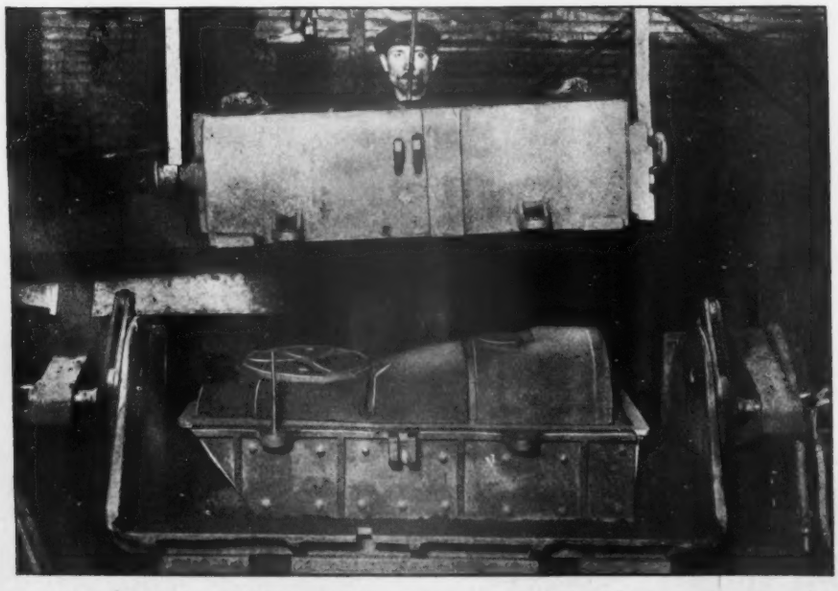


FIG. 7—CLOSING DRAG OVER DRY SAND CORE

transmission housings is unique since it involves the employment of a combination dry sand and green sand core. The mold is made on a pair of Osborn, direct-draw, roll-over jolt-ramming machines, this equipment being illustrated in Fig. 6. The machine in the foreground has been provided with a stripping plate attachment for ramming the drag half of the mold. The drag flasks are barred similar to the cope flasks. On the machine in the background is molded the cope half of the core and the cope half of the core box just being rolled over is clearly illustrated in Fig. 8. As previously stated, the drag half of the mold is made on the machine shown in the foreground in Fig. 6, and in this view the pattern is shown in molding position. After the drag has been jar-rammed, the drag pattern is stripped and the drag half of the mold is rolled-over.

Assembling the Mold

While the drag half of the mold is being made by two operators the green sand cope core likewise is being rammed on the direct-draw, roll-over jolt machine shown in Fig. 8. When this core is rammed and struck-off, the dry sand half of the core is placed in position on top of the green sand core, as illustrated in Fig. 7. The dry sand half of the core is located by a jig that conforms to the outlines of the core and to the pin holes of the flask or core box. After the dry sand core has been properly located the jig is removed. The drag flask then is raised by a small jib hoist located between the two molding machines, as illustrated in Fig. 6. After being lifted, the drag half of the mold is swung squarely over the core box on which has been placed the dry sand half of the core, as shown in Fig. 7. The drag half of the mold then is lowered in position and the flask is clamped to the core box. The drag half of the mold, with the cope core box then is rolled over, as shown in Fig. 8. The cope core box is drawn leaving the green sand half of the core in position on a dry sand half of the core. The dry sand core is in the drag half of the mold and the green sand half of the core is carried in the cope.

The drag half of the mold with the core in position pulled out from underneath the machine on the buggy on which the drag half is deposited, is shown in Fig. 8. It then is placed on the floor ready to receive the cope. The cope half of the mold is made on a machine similar to that on which the drags are produced and

this likewise is operated by two men. The flasks have machined joints and the print openings at either end are machined to the exact diameters of the prints.

Fig. 3 is a view of a floor of tractor transmission housing molds at 9 a. m. and in the foreground is shown one of the castings at *A*, immediately after shaking out; *BB* are print openings in the flasks which show also the core prints extending through them. Each casting weighs approximately 200 pounds and by the equipment as described, 100 molds are produced daily. Each mold weighs slightly in excess of 1000 pounds.

Leading Cores

Mr. Stoney also described the method of joining cores by the use of molten lead, as practiced at the plant of the Ferro Machine & Foundry Co. This system was described briefly in THE FOUNDRY, November, 1917, page 469. Additional details of this process, however, are given in the illustrations in Figs. 9 and 10. The jig used to hold two compression chamber cores and four port cores in position while the four port cores are being leaded to the compression chamber cores, is shown at *A*, Fig. 9, and at the right and held by a coremaker, is the assembled core. The openings into which the lead has been poured are indicated by *B*. In Fig. 10 a boy is pouring lead through the prints of the compression chamber cores into the port cores. All the assembling is done by jigs thereby insuring absolute uniformity and correct location. The lead may be reclaimed if the castings are permitted to set long enough for the lead to cool in the cores. The entire operation may be performed by boys who can assemble these cores as accurately as skilled coremakers; this, of course, is made possible by the use of the jigs. This method of leading is used extensively in the Ferro plant for uniting various cores and in many instances for holding cores in place in molds.

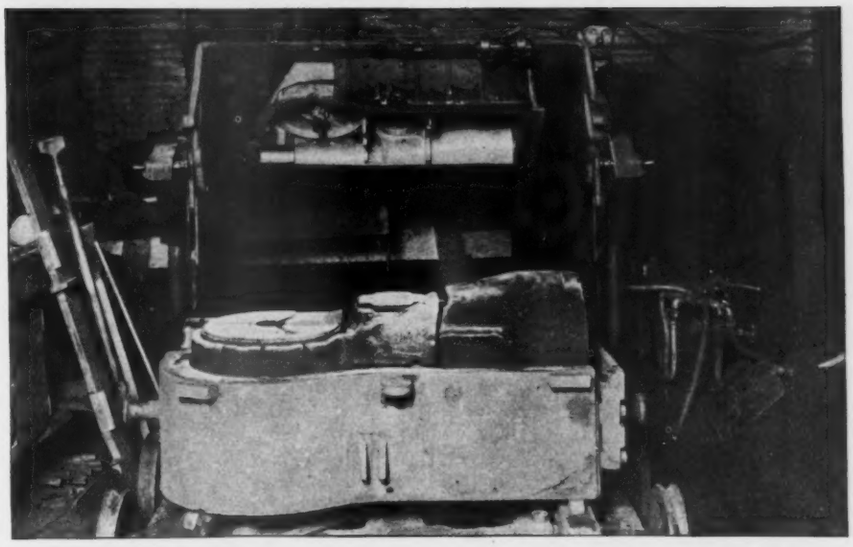


FIG. 8—DRAG ROLLED-OVER SHOWING GREEN SAND CORE DRAWN

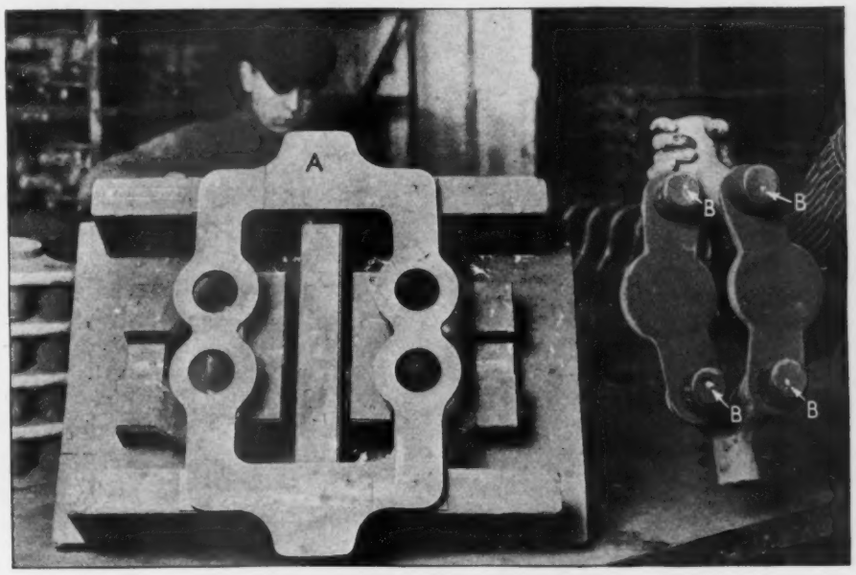


FIG. 9—JIG FOR ASSEMBLING CORES, *A*, AND LEADED CORES AT RIGHT

FIG. 10—BOY ASSEMBLING CORES BY THE LEADING PROCESS

Will Not Manufacture Iron Castings

In the April issue of THE FOUNDRY it was stated that the Pittsburgh Steel Foundry Co., Pittsburgh, would erect a plant for the manufacture of iron and steel castings. However, we have been advised that the office building of the company at Glassport, Pa., recently was destroyed by fire and that a small building will be erected to replace it. The company does not contemplate the manufacture of iron castings under its plans at present.

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Contents

	Page
No Relief in Sight From Pig Iron Shortage	189
Increased Sulphur Content for Steel Castings	191
Lead Production in 1917	192
Handling Government Work in a Steel Foundry	193
Cooling Rate Affects Steel Casting Design—I	201
Molding a Superheater Locomotive Cylinder	205
Car Wheel Difficulties	209
Estimating the Weights of Castings Rapidly	210
Machine Facilitates the Chilling of Castings	212
Use Drawings to Influence Shop Efficiency	212
What is the Matter With My Nickel Solution?	213
Asbestos Used to Prevent Stools From Burning Onto Crucibles	215
Molding and Casting Ornamental Bronze Tablets	216
Institute of Metals to Merge With Mining Engineers	217
Properties of Manganese Bronze Test Coupons	218
Melting Aluminum in an Oil-Fired Furnace	219
Mixture for Aluminum Bronze	219
Mixtures for Steam Goods	219
Solders for Brass and Aluminum	219
Melting Yellow Brass	219
Oxidation of Copper	220
Bronze Castings to be Subjected to Hydraulic Pressure	220
Excessive Shrinkage of Aluminum	220
Adding Ferromanganese to Brass Mixtures	220
Black Bell Metal Alloy	220
Waste Heat Boiler for Malleable Furnaces	221
Removal of Phosphorus and Sulphur in the Cupola	226
Growth of Gray Cast Iron by Repeated Heating	227
Auto Engine for Cupola Blower	229
Another Original Pamphlet	229
Regulus Metal Mixture	229
Molding Machines Facilitate the Production of Castings for Tractors	230
Steel Casting Inspection Criticised	234
Personal	235
An Electrically-Operated Riddle	236
Hard Iron Mixture	236
Melting Copper Alloys	236
Tapering of Core Prints	237
Cupola Lining Burns Out and the Iron is Dull	237
Relative Shrinkage of Pig Iron and Scrap	237
What the Foundries Are Doing	238
New Trade Publications	238

Steel Casting Inspection Criticised

INEXPERIENCED, critical and faulty inspection is claimed to be delaying the production of steel castings for the government and for the purpose of speeding-up output, the Steel Founders' Society of America has recommended the establishment of a central inspection bureau. This plan would make it possible for one corps of men to make inspections for all departments of the government. In addition, they would devote all their time to steel castings with the result that because of their experience they could exercise discretionary powers not now possible. It has been the experience of all steel foundrymen that many cases arise in which castings meet the spirit of the specifications, but vary in some detail with the letter of the standard requirements. Because of inexperienced inspection, hundreds and thousands of steel castings have been allowed to accumulate until the red tape at Washington could be unwound to get some special ruling. Furthermore, the percentage of rejected castings is out of proportion with commercial practice. The British government found it desirable to combine its inspection forces and inspection was expedited further by restricting it to samples instead of going into detailed examination. Here, nothing but the inspection of the casting itself will suffice. In addition, the stamping of the heat number on each casting is a needless operation that harks back to the days when our gold-laced ordnance officers devoted their time to devising ways and means for making it almost impossible for manufacturers to produce according to outlined specifications. However, *we are now at war. The time has arrived for action.* These traditionary practices should be pigeon-holed and a few common-sense methods should be introduced. The number of inspections to which castings are subjected in steel shops is a joke. Why castings should be inspected immediately after shaking-out, no one in the foundry business has been able to fathom. The added handling thereby imposed on the shop greatly retards the cleaning and finishing operations and the congestion slows-up production generally. And steel castings must not be welded! At least many of the so-called government inspectors believe this to be a heinous crime. They do not know the high state of development attained by the welded, before they are inflicted upon the steel foundry-accomplished by this method of repairing defects. If the inspectors are without knowledge of this important subject, they should be given a course of instruction on what defects may and may not be welded before they are inflicted upon the steel foundrymen of the country. An immediate unification of all steel casting specifications for the various departments of the government is essential to the prosecution of our war program. If the diversified commercial interests of the country can abide by one steel casting standard there is no reason why the petty differences of the various government departments cannot be co-ordinated—at least for the period of the war—sufficiently to permit of the adoption of one set of specifications for all government steel casting purposes.

Personal

Herbert Longstaff has been appointed manager of the St. Louis office of the Asbestos Protected Metal Co., Pittsburgh.

Cassius M. Miller of the Basic Mineral Co., Pittsburgh, is a candidate for congress in the 29th district of Pennsylvania which includes a large part of Pittsburgh.

Robert J. Carroll has been elected president and treasurer of the Carroll Foundry & Machine Co., Bucyrus, O. He is a son of the late P. J. Carroll, who owned the Carroll company.

Earl B. Morgan, formerly safety engineer of the Norton Co., Worcester, Mass., has been appointed assistant chief engineer of the Liberty Mutual Insurance Co., Boston.

R. H. Shaw, formerly connected with the West Michigan Steel Foundry Co., Muskegon, Mich., has been appointed foundry foreman of the Acme Steel Co., Akron, O.

W. J. Gilmore, formerly foundry superintendent of the plant of the American Steel Foundries, Indiana Harbor, Ind., has been appointed works manager of the Hubbard Steel Foundry Co., East Chicago, Ind.

F. W. Olsen has been appointed general purchasing agent for all of the plants of the United States Radiator Corp., whose general offices are at Detroit. Mr. Olsen succeeds the late B. F. Rennison.

C. Smith, formerly production clerk of the foundry operated by the J. I. Case Threshing Machine Co., Racine, Wis., has been appointed foundry superintendent to succeed R. LaPoint, who resigned recently.

E. J. Morrow has resigned as superintendent of the foundry operated by the Metals Production Equipment Co., Springfield, Mass., and has accepted a position as manager of the Mansfield Foundry Co., Mansfield, Mass.

A. E. Ward has been appointed sales manager of the International Oxygen Co., 115 Broadway, New York. Mr. Ward formerly was affiliated with the Prest-O-Lite Co., Indianapolis.

William H. Reese, formerly secretary of the convention bureau of the Milwaukee Association of Commerce, has resigned to accept the position of advertising manager of the Sterling Motor Truck Co., of that city.

Frank Haber has been elected a director of the Central Foundry Co., New York, to fill the vacancy caused by the retirement of Waddill Catchings from the board. DeCourcey Cleveland and S. J. Leonard have been elected directors for the three-year term.

D. B. Clark, formerly shell department superintendent of the American Brake Shoe & Foundry Co., Erie, Pa., has been appointed general superintendent of the Watervliet arsenal, Watervliet, N. Y., in charge of the plant's entire production.

Major Edgar Allen Custer addressed the Pittsburgh Foundrymen's association, April 15, on "The Manufacture of Semisteel Projectiles". He is chief in charge of inspection of all ordnance material produced in the Pittsburgh district.

A. W. Ferguson, service department manager of *Concrete*, published at Detroit, has resigned to take charge of sales for the Blystone Mfg. Co., Cambridge Springs, Pa., builder of machinery used for mixing foundry sands, concrete, mortar and plaster.

J. G. Shaw, formerly affiliated with the Milwaukee Steel Foundry Co., Milwaukee, is president of the recently organized Shaw Foundry Co., of that city. The plant produces gray iron castings. Mr. Shaw also is president of the Acme Steel Co., Akron, O.

J. A. Moore, after an absence of two years, again has assumed the position of superintendent of the foundry of the American Blower Co., Detroit. In the meantime he was foundry superintendent of the Russell Wheel & Foundry Co., Detroit, but resigned recently.

F. G. Peterson has been appointed foundry foreman of the casting plant operated by the Bucyrus Co., South Milwaukee, Wis. For many years he was connected with the Pratt & Letchworth Co., Buffalo, and subsequently he was with the Stock Steel Process Co., Detroit.

F. J. Herman has severed his connections with the estate of W. J. Rainey, large coke operators in the Connellsville region, to devote his entire attention to his duties as chief assistant to W. S. Blauvelt, director of the coke division of the fuel administration.

George L. Danforth Jr. has been appointed general superintendent of the south works of the Illinois Steel Co., to succeed Herman A. Brassert, resigned. Mr. Danforth is the originator of many important improvements in open-hearth practice and in open-hearth furnace construction.

William H. Barr, president of the Lumen Bearing Co., Buffalo, and president of the National Founders' association, and H. H. Rice, Detroit, past president of the National Metal Trades association, were speakers at the annual meeting and banquet of the New Haven, Conn., branch of the latter organization, April 3.

Joseph Risney, formerly superintendent of the foundry operated by the Iowa Valve Co., Oskaloosa, Iowa, has been appointed foundry superintendent of the new plant operated by the Davis Mfg. Co., Milwaukee, builder of tractor engines. F. N. Davis is president of this company, and W. I. Denny, purchasing agent.

Thomas O'Neil, formerly affiliated with the Hercules Gas Engine Co., Evansville, Ind., has succeeded George W. Thexton as assistant to John D. Bird, general manager of the Cudahy, Wis., plant of the Henry R. Worthington Co. Mr. Thexton has been appointed works manager of the Bucyrus plant, South Milwaukee, Wis.

E. A. Taylor, formerly general superintendent of the Dayton plant of the Maxwell Motors Co., and who recently occupied the same position at the Chalmers plant of the Maxwell company in Detroit, has been appointed general production superintendent of all of the Maxwell plants. He succeeds C. W. Adams, who has been appointed general factory manager. Myron Holzapple, Mr. Taylor's assistant at Detroit, has been appointed general superintendent of the Chalmers plant.

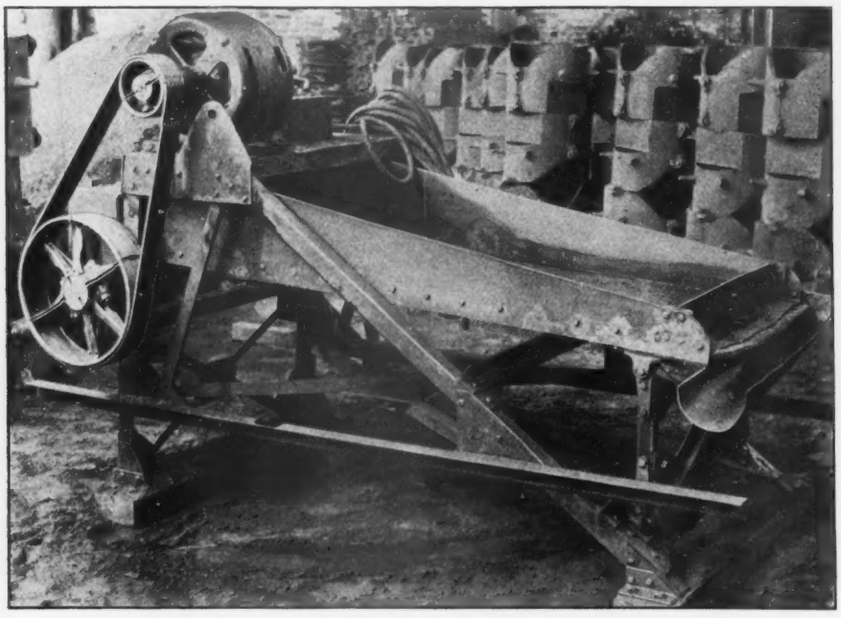
A number of changes recently have been made in the organization of the Chain Belt Co., Milwaukee. L. C. Wilson has been appointed assistant to President Frey, and W. T. Hersher, for many years assistant superintendent of the Bridgeport Malleable Iron Works, Bridgeport, Conn., has been named superintendent of the malleable plant. Clifford Merwin of Holyoke, Mass., is in charge of factory production, and E. C. Wilson, formerly with the Foos Gas Engine Co., Springfield, O., has been appointed purchasing agent.

Charles Philip Coleman, recently elected president of the Worthington Pump & Machinery Corp., New York, occupied the position of vice president since May, 1916, and prior to that date he served in the capacity of receiver of the International Steam Pump Co. and associated companies which now have been reorganized into the present corporation. Mr. Coleman is a graduate of Lehigh university, and was employed by the Lehigh Valley railroad in various capacities until 1903. At that time he was elected secretary and treasurer of the Singer Sewing Machine Co. and subsequently he became president of the Saurer Motor Co. In 1913 he was elected vice president of the International Steam Pump Co. and in 1914 he was appointed co-receiver which was followed by his selection as sole receiver in 1915.

An Electrically-Operated Riddle

The motor-driven riddle for screening molding sand, shown in the accompanying illustration, is being built for the foundry trade by the Rodgers Boiler & Burner Co., Muskegon, Mich. Before placing this device on the market, it was subjected to severe casting plant service for a period of 18 months.

The screen is operated by a shaft to which is attached a 16-inch pulley with a 6-inch face. It is belted direct to the motor, which is of two-horsepower capacity, and is mounted on a plate on top of the machine, thereby preventing contact with the sand.



MOTOR-DRIVEN RIDDLE FOR SCREENING FOUNDRY SAND

Clods of sand, nails, particles of iron and other foreign substances are carried by gravity to the front end of the screen, falling into an inclined trough from which they are deposited on the floor or may be loaded into a wheelbarrow direct.

The riddle is of rigid construction, steel plates and steel angles being used throughout. The screen is the only part subjected to wear. Two screens are provided with each riddle, one for molding and the other for facing sand. It is claimed that the screens may be changed with little loss of time. The riddle has a large capacity, two carloads of sand having been screened in one shop in 2¼ hours.

According to preliminary estimates made by the United States geological survey, the production of blister and lake copper from domestic ores in 1917 was 1,890,000,000 pounds as compared with 1,928,000,000 pounds the previous year. The output of refined copper, including electrolytic, lake, casting, and pig, from primary sources, domestic and foreign, for 1917 is estimated at 2,362,000,000 pounds as against 2,259,000,000 pounds for 1916. At an average price of about 27 cents a pound, the output for 1917 was valued at $510,000,000 against $475,000,000 in 1916.

Hard Iron Mixture

By W. J. Keep

Question:—Kindly furnish me with a mixture for hard iron that will have good resistance qualities. I have used a mixture containing 10 per cent steel, 50 per cent white iron and the balance high-manganese pig, but the iron is soft.

Answer:—The fact that there is a large malleable iron foundry located in your town suggests that you are using the same white iron used by this plant, but which, unfortunately, is not a chilling iron. The easiest method for you to procure the desired results is to use old car wheel scrap, which contains the proper mixture for your work. If too hard, you can soften it with your high-manganese pig iron. White iron suitable for malleable work is non-chilling. On the other hand, if it is suitable for car wheels, it is a chilling iron. Run some of your molten iron against the chill and see how it acts. By adding spiegeleisen to the mixture in the cupola, you can make the iron as hard as desired and by keeping up the silicon, the iron will still be gray and very strong. However, try old car wheels in your mixture to increase the chilling properties.

Melting Copper Alloys

At a recent meeting of the Birmingham, Eng., Section of the British Institute of Metals, a paper on "Metal Melting with Special Reference to Brasses and Bronzes" was presented by H. L. Reason. The author stated that to successfully produce copper alloys, too much attention cannot be given to the process of melting, and that a large number of defective castings are produced by permitting the metal to remain in the furnace after the required temperature has been attained, by overheating the metal, by pouring too hot or too cold and to oxidation. He emphasized the necessity of careful melting as a preventative of oxidation and pointed out that unless furnaces and chimney stacks are properly designed to insure melting the metal at the correct speed, the best results cannot be obtained. The proper speed for melting brass after the first heat in coke-fired, lift-out crucible furnaces with natural draft, he claimed is from 40 to 60 minutes for pots holding up to 300 pounds of metal. A covering of charcoal is necessary if good metal is to be obtained.

The melting and boiling points of the principal metals used in brass foundry practice were given as follows:

	Melts, degrees Fahr.	Melts, degrees Cent.	Boiling point, degrees Cent.
Copper	1981.5	1083.0	2310.0
Zinc	786.9	419.4	905.7
Tin	449.4	231.9	1450 to 1600
Lead	621.1	327.4	1525.0

The difficulty often experienced in securing unsound copper castings was stated to be due to the metal not being raised to the correct casting temperature. The copper should be melted as quickly as possible to nearly boiling point, under a cover of charcoal, and just before removing it from the furnace to pour itno the molds, a small amount of phosphorus should be added. A number of melting furnaces were described, one of which was adapted for use with either oil, coke or gas. It had a melting speed of 70 minutes for an 800-pound heat of 60-40 brass. When using oil, from 1¼ to 1½ gallons of creosote or tar oil were consumed for each 112 pounds of metal melted. The blast pressure for this fuel was one pound, and for heavy Texas or Mexican oils, two pounds. Mr. Reason contended that phosphorus is the best flux for bronze. For brass, a flux of four parts salt and one part soda ash gives good results.

The McLain-Carter Furnace Co., Milwaukee, has been awarded a contract by the Warren Steel Casting Co., St. Louis, for the installation of a 5-ton oil-fired open-hearth furnace. The furnace is to be completed and in operation in 45 days.

The Tapering of Core Prints

By M. E. Duggan

In the April issue of THE FOUNDRY, F. J. Townsend asks whether bottom core prints should be tapered the same as top prints. This may seem to be of trifling importance, but on several occasions in watching the operations of molders, I learned that the patternmaker's disregard for these so-called trifles in the making of a great many patterns has caused difficulties in producing the molds and also has resulted in bad castings. Several days ago, one of these trifles was directed to my attention by the foreman of a foundry. I made a core box which I thought to be so plain and simple that no mistake could be made in its construction. Nevertheless, the mistake *was* made and the only reason I was not asked to alter the corebox was that the coremaker was willing to take a chance in producing a satisfactory core from it as I made it.

Referring to the tapering of core prints, Mr. Townsend states that this subject might be discussed by foundrymen generally. However, he forgot to include patternmakers. The latter determine how the molder is to mold the pattern and therefore, the molder is controlled in his operations by the patternmaker. While Mr. Townsend is of the opinion that the tapering of core prints, apparently, is for foundrymen to decide, nevertheless in the majority of cases the decision of the foundryman rarely is conveyed to the journeyman patternmaker and he never learns of these trifling, though important considerations, except by accident or through one of the technical journals.

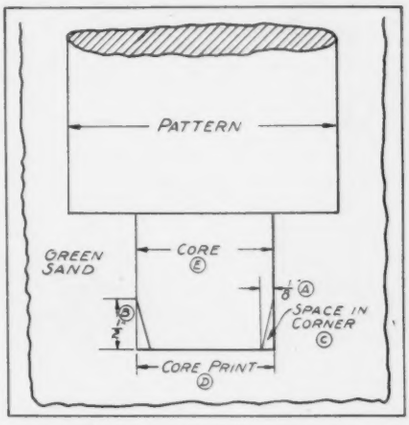
I discussed Mr. Townsend's question with several molders and they stated that they prefer a straight core print in the drag as it is an aid to the molder in setting and centering the core. Referring to "Wood Patternmaking", by Purfield, we find the following: "A great many castings are lost because the lower print of vertical cores are made nearly parallel, or with the ordinary pattern draft. The probable cause of this is that the core does not go down to the bottom of the mold since the sand is cut down by the core in setting." In other words, the core, as it is being pressed down, cuts away the sand which is deposited in the bottom of the core pocket.

In the accompanying illustration is shown a straight core print, with a core a combination of both the straight and tapering types. The tapered core provides a pocket to receive the loose sand without interfering with the correct setting of the core. These cores may be tapered as desired either by machines or by the molder with a file.

Cupola Lining Burns Out and the Iron is Dull

By W. J. Keep

Question:—The lining of our cupola, which has a diameter of 38 inches, burns out rapidly and we would like to know how to obviate this difficulty. The cupola is charged level with the door before the blast is turned on and notwithstanding that the fire is lighted about two hours before applying the blast, gas does not show through the charge for 20 minutes thereafter. The bed consists of 1100 pounds of coke and 2000 pounds of iron. This is followed by seven charges of 150 pounds of coke and 1500 pounds of iron, in the proportion of 900 pounds of pig and 600 pounds of scrap. The last charge consists of 40 pounds of coke and 800 pounds of iron, making a total melt of 13,300 pounds. The iron frequently is very dull at the end of the heat. Our product consists largely of light machinery castings.



STRAIGHT CORE PRINT WITH A CORE WHICH IS A COMBINATION OF BOTH THE STRAIGHT AND TAPERING TYPES

Answer:—Your melting practice and your equipment should give you satisfactory results. To prevent dull iron, close the damper and cut off the upper row of tuyeres 30 minutes before the heat is off. As a matter of fact, it is more advisable to close the upper row of tuyeres entirely. To prevent the lining from burning out you may be obliged to reduce your blast slightly to prevent it from reaching the lining, although you fail to state the blast pressure. To accomplish this, provide a valve opening in the pipe, which may be graduated or closed entirely, as desired, or perhaps it already is equipped with an automatic relief valve which may be left partly open. In patching the lining, if the holes are deep the brick should be chipped out and should be replaced by a new piece of brick, instead of merely filling with daubing material. To prevent it from falling off, apply as little daubing material as necessary. In charging do not throw into the cupola the sweepings from the charging floor, but screen out the iron from these accumulations. The cupola should be slagged and the slag hole should be opened as soon as the slag will run; for example, after the third charge.

You state that the gas does not come through the charge for 20 minutes after the blast is on. You also state that the bed consists of 1100 pounds of coke, but in your cupola report it is given at 950 pounds. For the purpose of gaging the coke bed, bend a ⅜-inch rod at right angles and in opposite directions at either end, so that when suspended from the charging door sill the other end will be 20 inches above the tops of the lower tuyeres. After you have heated the cupola two hours and just before charging iron, hang the rod in the door and fill in coke until it touches the other end of the rod. If you use the upper tuyeres, the rod should be bent at a point 15 inches above the upper tuyeres. In this way you will be able to ascertain if the height of your bed is right. If there is any tendency to dullness, extra coke should be charged to increase the temperature of the metal.

Relative Shrinkage of Pig Iron and Scrap

By W. J. Keep

Question:—A statement has been made that the more frequently cast iron is melted the higher its shrinkage will become. It also is reported to us that scrap iron shrinks more than pig iron. Will you kindly advise us whether this is correct?

Answer:—Both of these statements are correct. Shrinkage is caused by an increase of sulphur and a decrease of silicon, which cause an increase of combined carbon. A single melting will cause a loss of 0.30 per cent silicon and an increase of 0.03 per cent sulphur. By increasing silicon you will make up for the loss and can partially overcome the influence of sulphur, but not entirely because the silicon can only act on the carbon present and each melting decreases the total carbon. This loss cannot be replaced unless you are able to purchase pig iron rich in graphite as well as in total carbon. Phosphorus reduces shrinkage more than silicon and up to 1 per cent does not weaken castings enough to do harm. Phosphorus also keeps iron fluid; therefore, you can fill a mold with colder iron which shrinks less.

WHAT THE FOUNDRIES ARE DOING

Activities of the Iron, Steel and Brass Shops

The American Brass Co., Waterbury, Conn., has let a contract for a brick, steel and concrete, fireproof, 50 x 105-foot mill building.

The Columbia Malleable Castings Co., Columbia, Pa., contemplates erecting a $10,000 addition to its plant.

The Hubbard Steel Co., East Chicago, Ind., is building another steel foundry building, 200 x 600 feet.

J. L. Sparks, 320 West Grand avenue, Chicago, is building a foundry, 50 x 75 feet at 1723 Carroll avenue.

The Allis-Chalmers Mfg. Co., West Allis, Wis., will build a foundry addition, 150 x 200 feet. Otto Falk is president.

The Birdsboro Steel Foundry & Machine Co., Elk Lick, Pa., has let the contract for an addition, 40 x 135 feet, to its foundry.

The Gray Iron Castings Co., Mount Union, Pa., will fit up a plant on East Donegal street.

The Keystone Bronze Co., Pittsburgh, has let a contract to the Lawrence Steel Products Co. for an addition, 86 x 148 feet, to its foundry on Thirty-ninth street.

The Hercules Steel Castings Co., Milwaukee, will build a steel foundry, 80 x 300 feet, costing $100,000. E. B. Generich, 1102 Wells building, is secretary.

The Gary Foundry & Machine Co., East Gary, Ind., is building an addition 24 x 86 feet to its foundry, and two pattern storage buildings. W. H. Kleppinger is president.

The Lansdale Foundry Co., Lansdale, Pa., has let a contract for an addition 40 x 60 and 40 x 50 feet. H. I. Landis is president of the company.

The Universal Foundry Co., Warren and Pine streets, Oshkosh, Wis., has increased its capital from $10,000 to $25,000, and will build an addition. R. Zibell is president.

A. J. O'Leary & Son, Lake and Jefferson streets, Chicago, will build an addition 60 x 70 feet, plans having been made by L. H. Heinz, architect, 128 North La Salle street.

The Western Foundry & Machine Co., Moline, Ill., capitalized at $30,000, has been chartered by J. H. Johnson, A. C. Sinclair and R. S. Sinclair to operate a foundry.

To accommodate increased business, the Atlas foundry, Tacoma, Wash., has started the construction of an addition to its plant at South Thirtieth and Alaska streets.

Plans are being prepared for remodeling the foundry of the Welland Iron & Brass Co., Welland, Ont., and new machinery will be installed. E. J. Anderson is the manager.

The general offices of the Maxwell Motor Co., Detroit, have been moved from Woodward and Warren avenues, to the Chalmers plant.

The plant of the Monarch Steel Castings Co., Detroit, which was partially destroyed by fire recently, will be repaired immediately. J. H. Barry is manager.

The Consolidated Press Co., Hastings, Mich., contemplates the erection of a gray iron foundry for the production of castings which it now purchases in the open market.

The Brown Foundry, Stamford, Conn., has commenced work on a new building, 90 x 130 feet. This concern is now working indirectly for the government on brass castings and marine engines.

The Pelton Steel Co., Milwaukee, is having plans prepared for a foundry, 84 x 160 feet, with a wing, 65 x 85 feet. Schuchardt & Judell, 508-510 First National Bank building, are the architects.

Part of the foundry and core shop of the Kennedy Foundry Co., Baltimore, recently were destroyed by fire. Operations, although inconvenienced, have been continued and repairs will be made immediately.

The Malleable Iron Fittings Co., Meriden, Conn., has let a contract for a concrete and stone, 2-story, 61 x 121-foot addition and a 1-story, 40 x 50-foot building for the storage of patterns.

The foundry of the Rosenthal Corn Husker Co., Milwaukee, operated in connection with the main works in West Allis, was badly damaged by fire on April 9. The building was 30 x 110 feet in size and will be rebuilt at once.

The Production Pattern & Equipment Co., Milwaukee, has been organized with a capital stock of $25,000 to manufacture wood and metal patterns, foundry, machine shop and factory equipment. Paul E. Keller and Otto Koblitz, are promoting the new concern.

The Connecticut Brass & Mfg. Co., Cheshire, Conn., has awarded a general contract to T. J. Pardy Construction Co., Bridgeport, Conn., for the construction of a plant addition. The new building will cost $15,000, and will be 1-story, 56 x 65 feet.

The Litchfield Foundry & Machine Co., Litchfield, Ill., has been sold to T. L. Bryce, William Baitman and D. H. Sweeney, all former employes. Mr. Bryce was general manager of the plant, Mr. Baitman formerly head draftsman and Mr. Sweeney was superintendent of the foundry.

Inducements are being offered the Wisconsin Aluminum Foundry Co., Manitowoc, Wis., to build a branch foundry at Rice Lake, Wis. If the plan is unsuccessful, a new company probably will be formed to erect and operate a plant of this kind.

The Worthington Pump & Machinery Corp., Fifth street, near Bent street, Cambridge, Mass., will erect a foundry. It will be built of structural steel, 60 x 300 feet and will cost $25,000. Plans are by the company's engineers. The Aberthaw Construction Co. is the contractor.

The plant of the Peerless foundry, Hamilton, O., of which George F. Dana is proprietor, recently was destroyed by fire, but will be rebuilt immediately and a complete line of foundry equipment will be installed. Mr. Dana would like to receive catalogs from manufacturers of foundry machinery.

NEW TRADE PUBLICATIONS

METAL SHEET TESTER.—The Pittsburgh Instrument & Machine Co., Pittsburgh, Pa., has published an 8-page bulletin devoted to a recently patented metal sheet tester designed for drawing, stamping, compressing, and folding sheets of iron, steel, brass, copper, gold and silver. In its construction the sheet tester may be compared with a micrometer; the graduations permitting measurements of the thickness of the material and the depth of impression by 1-1000th of an inch. The machine can be fastened upright on a bench or horizontally to a post. The bulletin furnishes a complete description of the machine proper and shows the manner in which the testing operations are consummated. A portion of the bulletin is also devoted to a hardness testing machine constructed on the Brinnell principle.

LADLES.—A 24-page bulletin, published by the Whiting Foundry & Equipment Co., Harvey, Ill., is devoted to the extensive line of ladles manufactured by this concern. While these metal conveyors essentially are built for iron, steel and malleable foundry use, large ladles for steel works also are constructed in various capacities to meet the needs of these plants. Practically every type of ladle is built, including gear-controlled crane ladles, crane truck ladles, standard truck ladles, slag truck ladles, bottom tap ladles, teapot spout ladles, etc. In addition, the Whiting company, in a 28-page bulletin, published a list of all plants in which its cupolas have been installed. For 35 years these gray iron melting furnaces have been built and during that period over 3000 have been installed in foundries all over the world.

OIL BURNER.—A 6-page pamphlet, devoted to oil burners, has been issued by the Foundry Equipment Co., Cleveland. This burner can be adapted to all foundry operations where fuel oils are essential. The construction of this burner is unique, the air being fed from the main air chamber through a hollow brass stem. The oil passes around this circular stream of air and at the end of a brass stem which controls the oil supply the oil is forced into the air stream at a sharp angle. This causes the oil to break into small particles and produces the primary mixing with the air. A second and larger outer stream of air cutting through the primary mixer effects a further atomization of the oil and provides the proper combination of oil and air for complete combustion. The burner connections provide for a ½-inch oil line and a 2-inch air line giving a wide range of feed of both oil and air.